AUTOMATED TRAFFIC SIGNAL PERFORMANCE MEASURES

Arizona

MCDOT Maricopa/Cochise/Apache Conference Rooms 1st Floor

Friday, September 26, 2014

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Utah - Brief Facts

- Population 2.9M (34th largest state)
  - By the year 2050 – projected population 5.4M (86% Inc.)
- Land Area: 84,900 sq. mi (13th largest state)

- 1908 Traffic Signals in the State of Utah
  - 1151 owned and operated by UDOT (60%)
  - 757 owned and operated by cities /counties (40%)
- All cities share same ITS communications
  - 88% of UDOT signals connected
  - 79% of non-UDOT signals connected

- All cities share ATMS

Opportunity – UDOT Executive Leaders - 2011

"What would it take for UDOT's traffic signals to be World-Class?"

"What's the trend – are signal operations improving, staying the same or getting worse?"

"What are our areas of most need?"

John Njord

Carlos Braceras

Some QIT Recommendations (July 2011)

- Require that communications and signal detection be maintained during projects.
- Transition from reactive to proactive signal maintenance by increasing signal maintenance funding.
- **Implement real-time monitoring of system health and quality of operations.**
  - Automated Traffic Signal Performance Measures (SPM's)

SPM Basic Concept

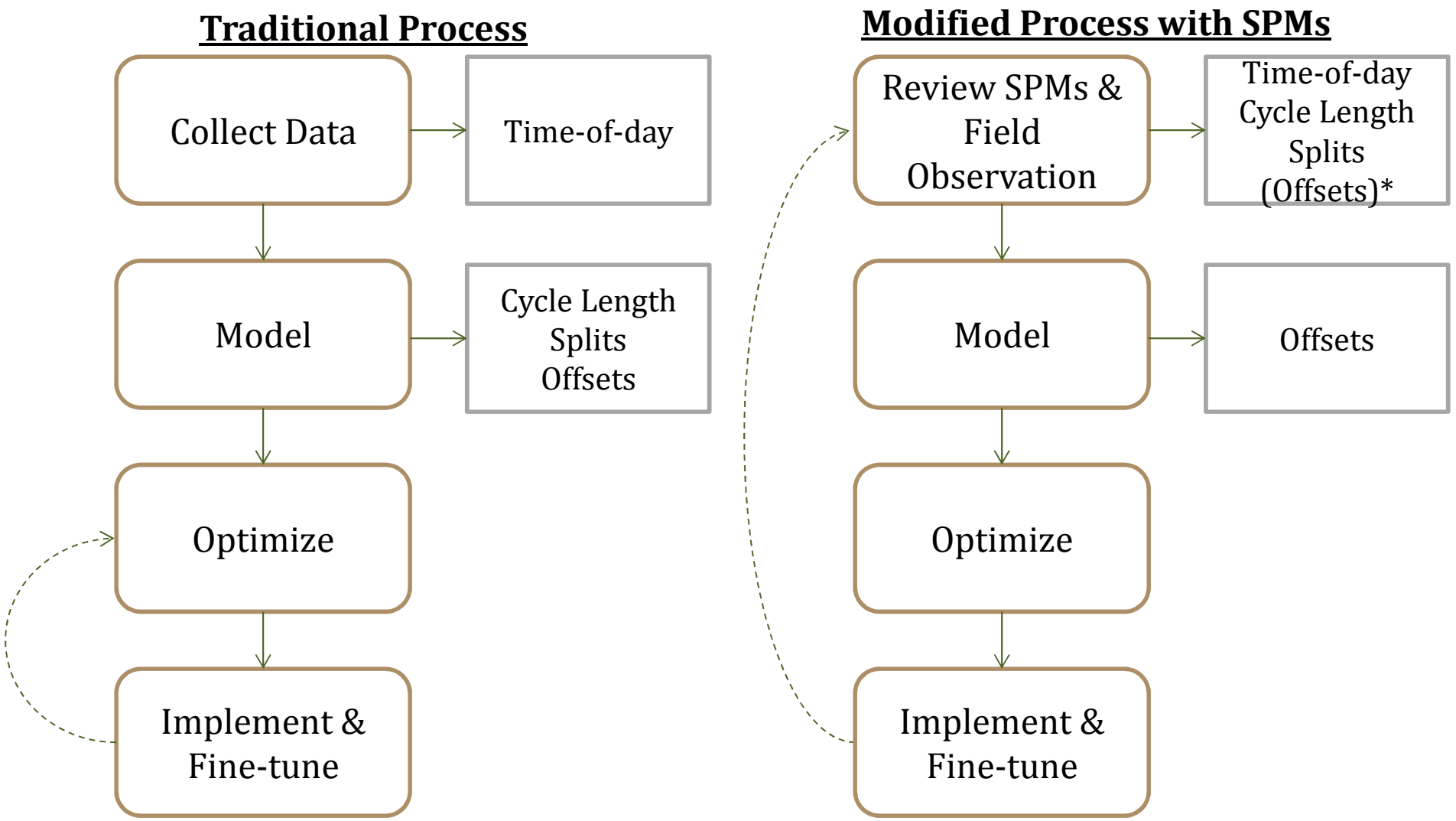
Automated Data Collection

- Signal controller
- Probe source

Useful Information about Performance

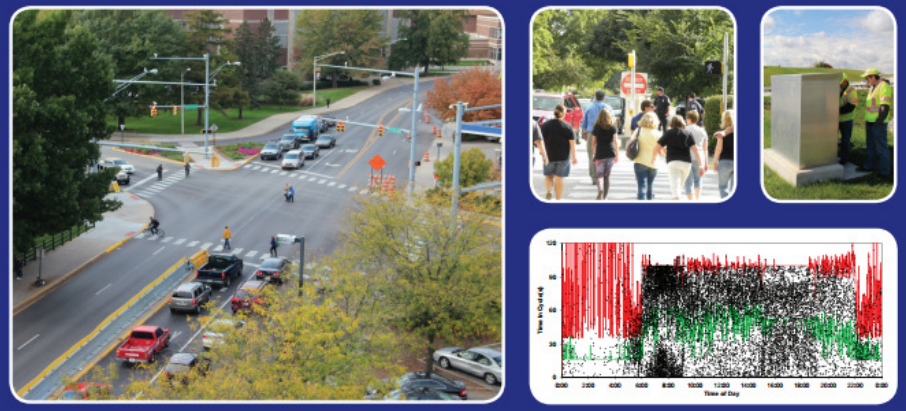
- Signal
- Corridor
- System

How SPM has Changed our Retiming Process



PERFORMANCE MEASURES FOR TRAFFIC SIGNAL SYSTEMS

An Outcome-Oriented Approach



Christopher M. Day, Darcy M. Bullock, Howell Li, Stephen M. Remias, Alexander M. Hainen, Richard S. Freije, Amanda L. Stevens, James R. Sturdevant, and Thomas M. Brennan

System Requirements for SPM's

1) High-resolution Controller

2) Communications

1) Get .dat Files
2) Translate Files
.dat → .csv
3) Store in Database

3) Server

- Econolite Cobalt: Any Version
- Econolite ASC3 NEMA: V. 2.50+ & OS 1.14.03+
- Econolite 2070 with 1C CPU Module: V. 32.50+
- Intelight Maxtime: V. 1.7.0+
- Peek ATC Greenwave 03.05.0528+
- Trafficware 980ATC V. 76.10+
- Siemens M50 Linux & M60 ATC
  - ECOM V. 3.52+
  - NTCIP V. 4.53+
- McCain – In Progress

1) Query Database
2) Display Graphs

4) Website

5) Detection
(optional)

Can be done independent of a central system!

Sample Controller Log

Detector 5 ON

Phase 8 GREEN

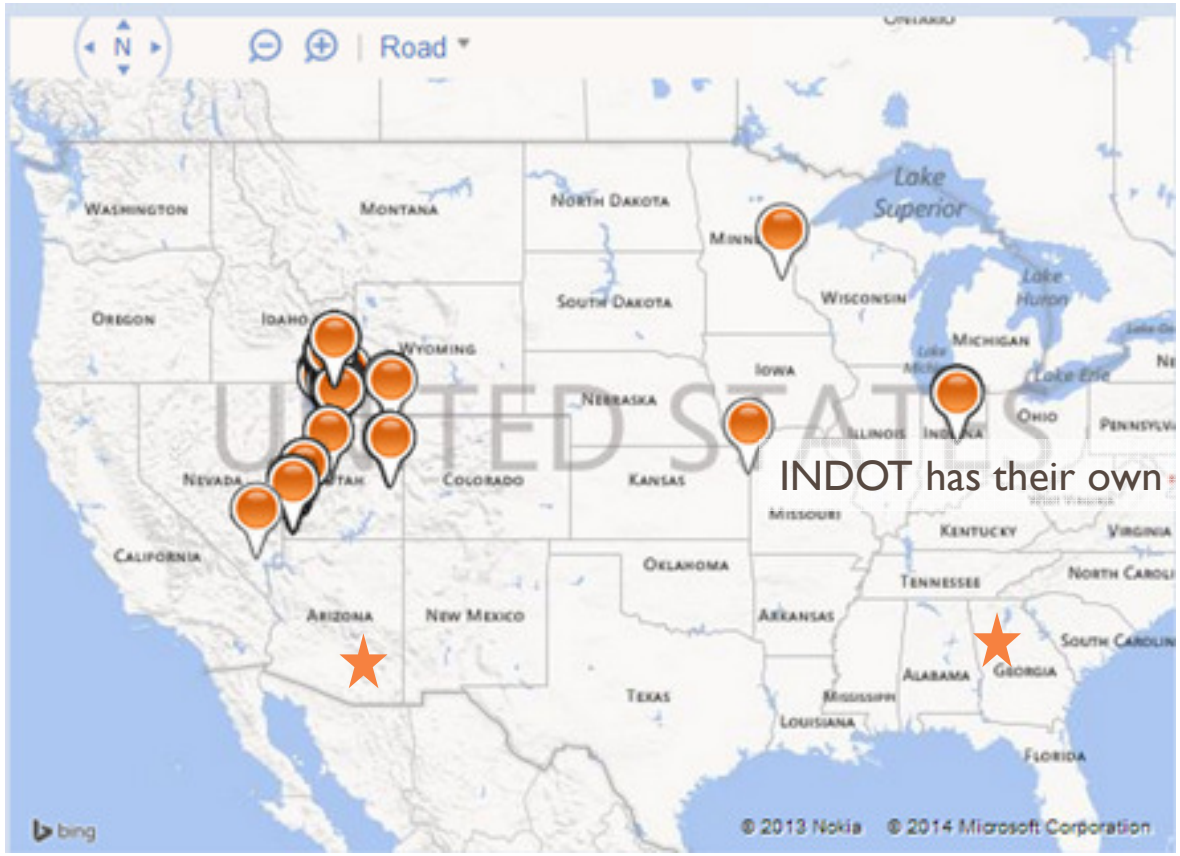
Detector 5 OFF

Timestamp	Event Code	Event Parameter
6/27/2013 1:29:51.1	10	8
6/27/2013 1:29:51.1	82	5
6/27/2013 1:29:52.2	1	2
6/27/2013 1:29:52.2	1	6
6/27/2013 1:29:52.3	82	2
6/27/2013 1:29:52.8	82	4
6/27/2013 1:29:52.9	81	4
6/27/2013 1:29:53.3	81	6
6/27/2013 1:29:54.5	81	2
6/27/2013 1:30:02.2	8	2
6/27/2013 1:30:02.2	8	6
6/27/2013 1:30:02.2	33	2
6/27/2013 1:30:02.2	33	6
6/27/2013 1:30:02.2	32	2
6/27/2013 1:30:02.2	32	6
6/27/2013 1:30:06.1	10	2
6/27/2013 1:30:06.1	10	6
6/27/2013 1:30:08.1	1	8
6/27/2013 1:30:13.1	32	8
6/27/2013 1:30:15.8	81	5
6/27/2013 1:30:18.5	82	6
6/27/2013 1:30:27.5	81	6
6/27/2013 1:30:30.4	8	8

Agencies using UDOT SPM Software

Others are in the works

Ask us if you're interested!

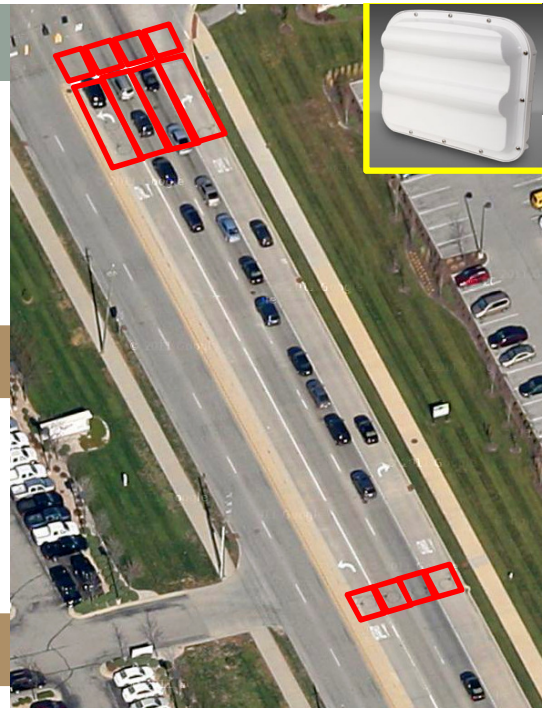


UDOT Providing the Source Code for FREE to Others

AASHTO Innovation Initiative

http://udottraffic.utah.gov/signalperformancemetrics

Types of Performance Metrics



Controller high-resolution data only

Purdue Phase Termination

Split Monitor

Advanced Count Detection (~350 - 400 ft behind stop bar)

Purdue Coordination Diagram

Approach Volume

Platoon Ratio

Arrivals on Red

Approach Delay

Executive Summary Reports

Link Pivot (future)

Advanced Detection with Speed

Approach Speed

Lane-by-lane Presence Detection

Split Failure (future)

Lane-by-lane Count Detection

Turning Movement Counts

Red Light Monitoring (future)

Probe Travel Time Data (GPS or Bluetooth)

Purdue Travel Time Diagram

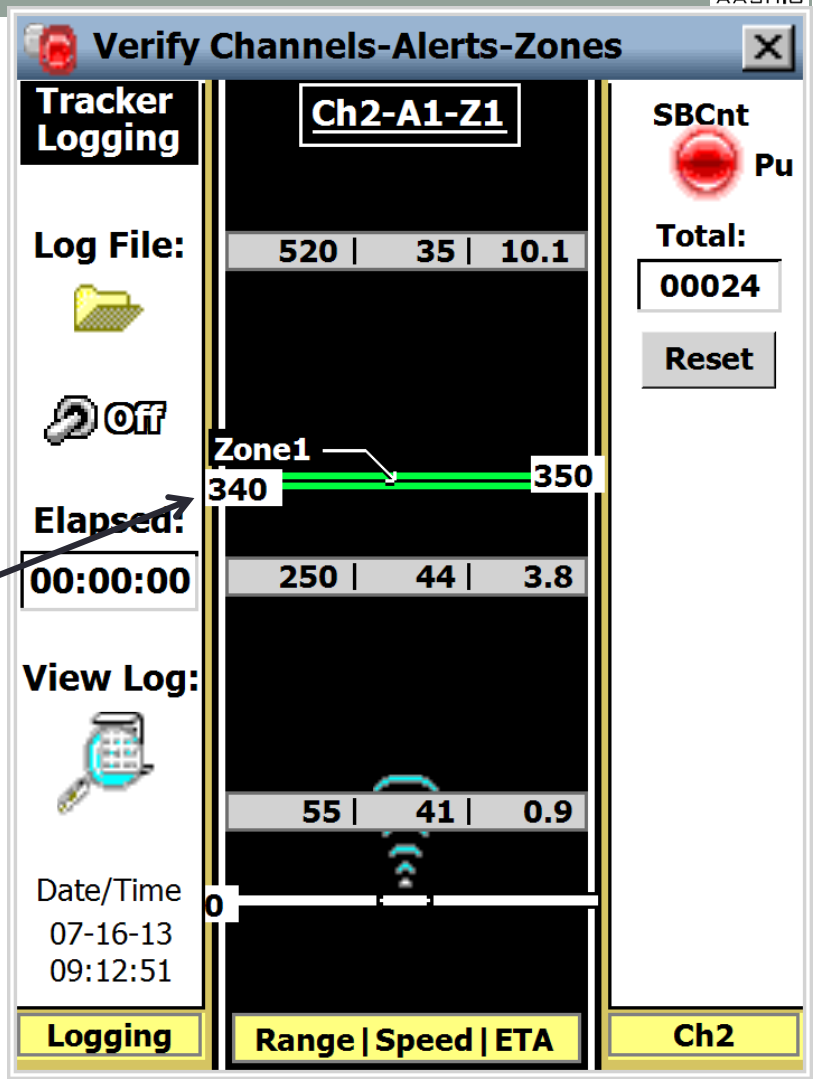
Advance Count Detectors

Wavetronix Advance

- Used to timestamp vehicle arrivals
- 10’ count zone placed ~350’ behind stop bar
- No additional expense if already in place for dilemma zones
- May undercount dense traffic
- Speed Metric only works with Wavetronix Advance Smartsensor

Loops & Pucks

- Also work too (except for speeds)



Count zone

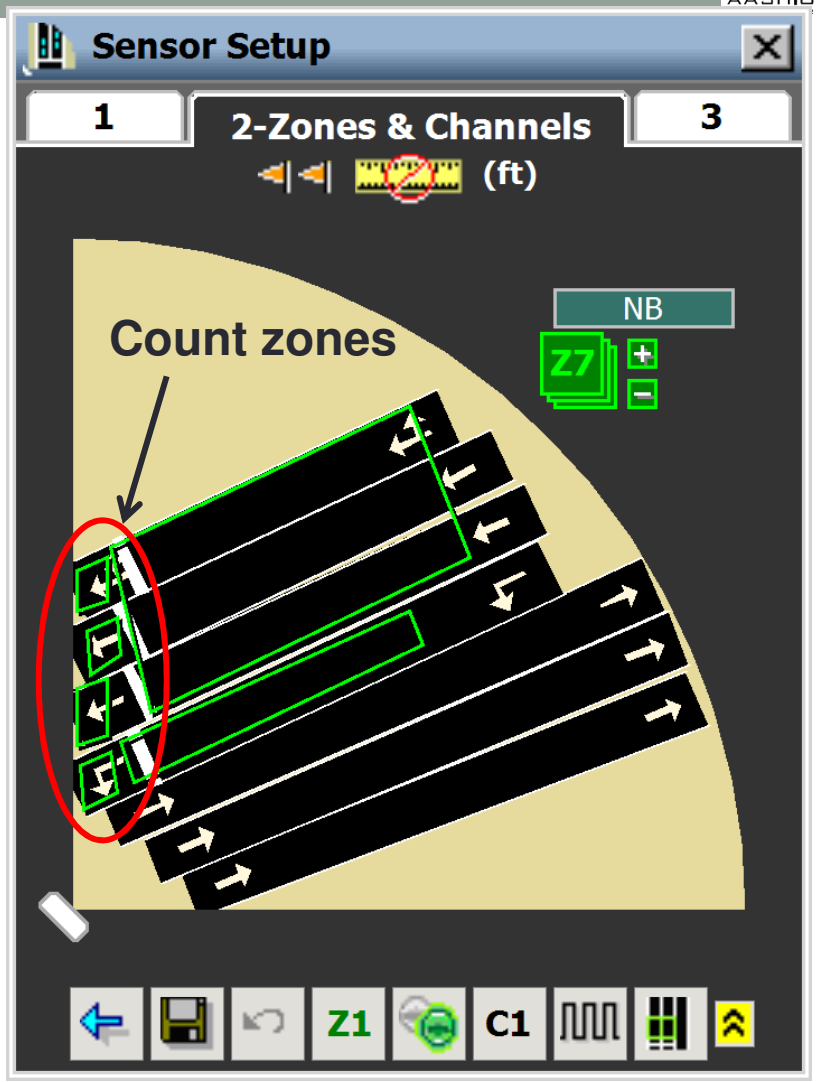
Stop Bar Count Detectors

Wavetronix Matrix

- Used for turning movement counts
- Lane-by-lane detection zones in front of stop bar
- Requires detection rack card for every two or four zones ($$$) or……..
  - Click 650 Detector BIU (64 channels)

Loops, Video, Pucks

- Work too.
- Need separate channel for each lane



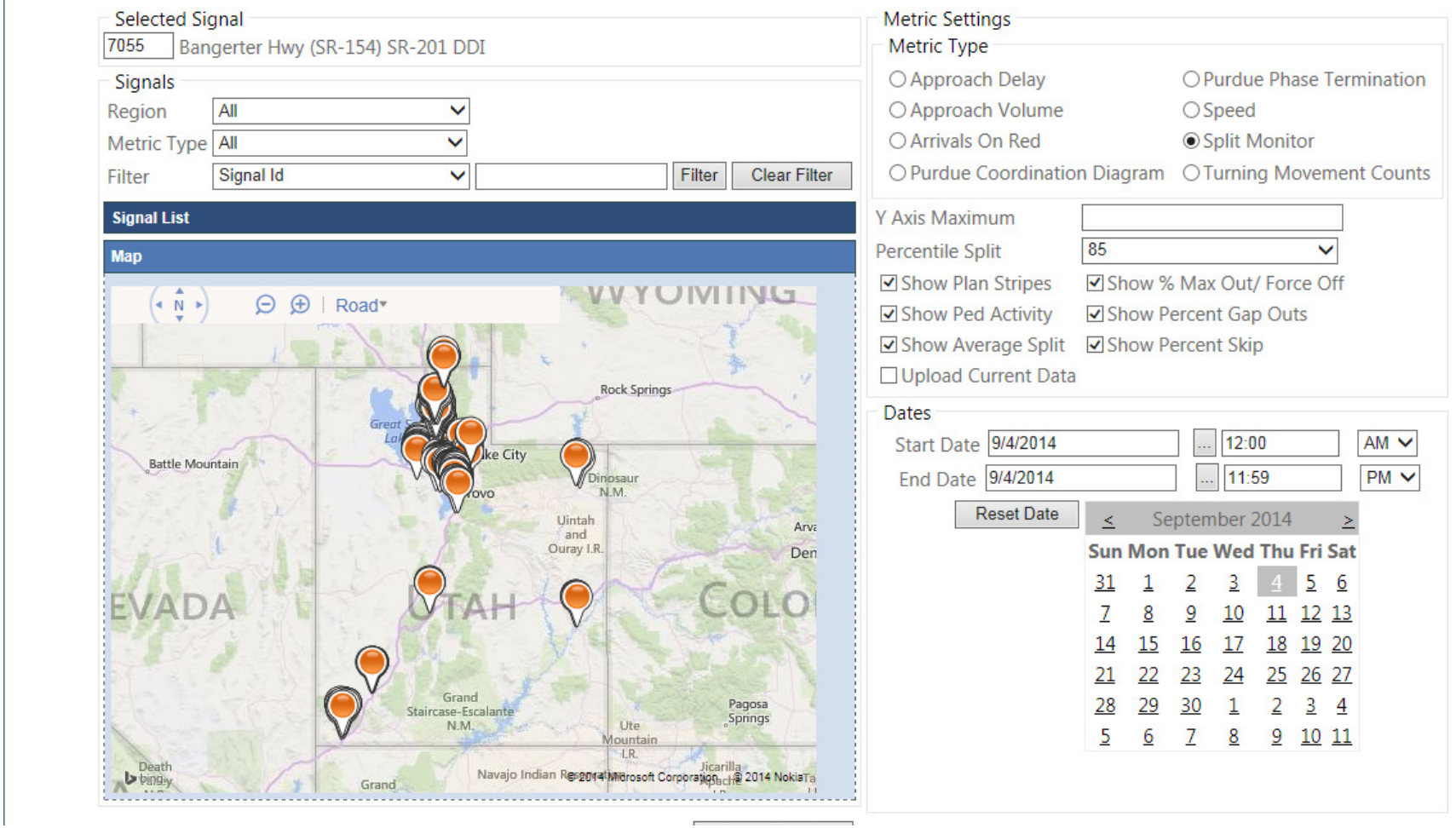
Performance Metrics Goals & Need

- Transparency and unrestricted access
  - No Special Software – No Passwords – No Firewalls
- Access for everyone
  - All of UDOT: (Safety, Region Traffic, Senior Leaders, Planning)
  - Consultants, Academia, MPO's, Federal gov., Local governments, Public
- The Need
  - Executive Leader Raising of the Bar & Challenge for World-Class Signals
  - Complaints were only measure we had
  - Look at it every few years for a few hours
  - Too much reliance on models and assumptions
  - What happens on the weekend stays on the weekend (same with holidays, middle of the night, …)

Signal Performance Metrics

Charts | Reports | Log Action Taken | Links | FAQ

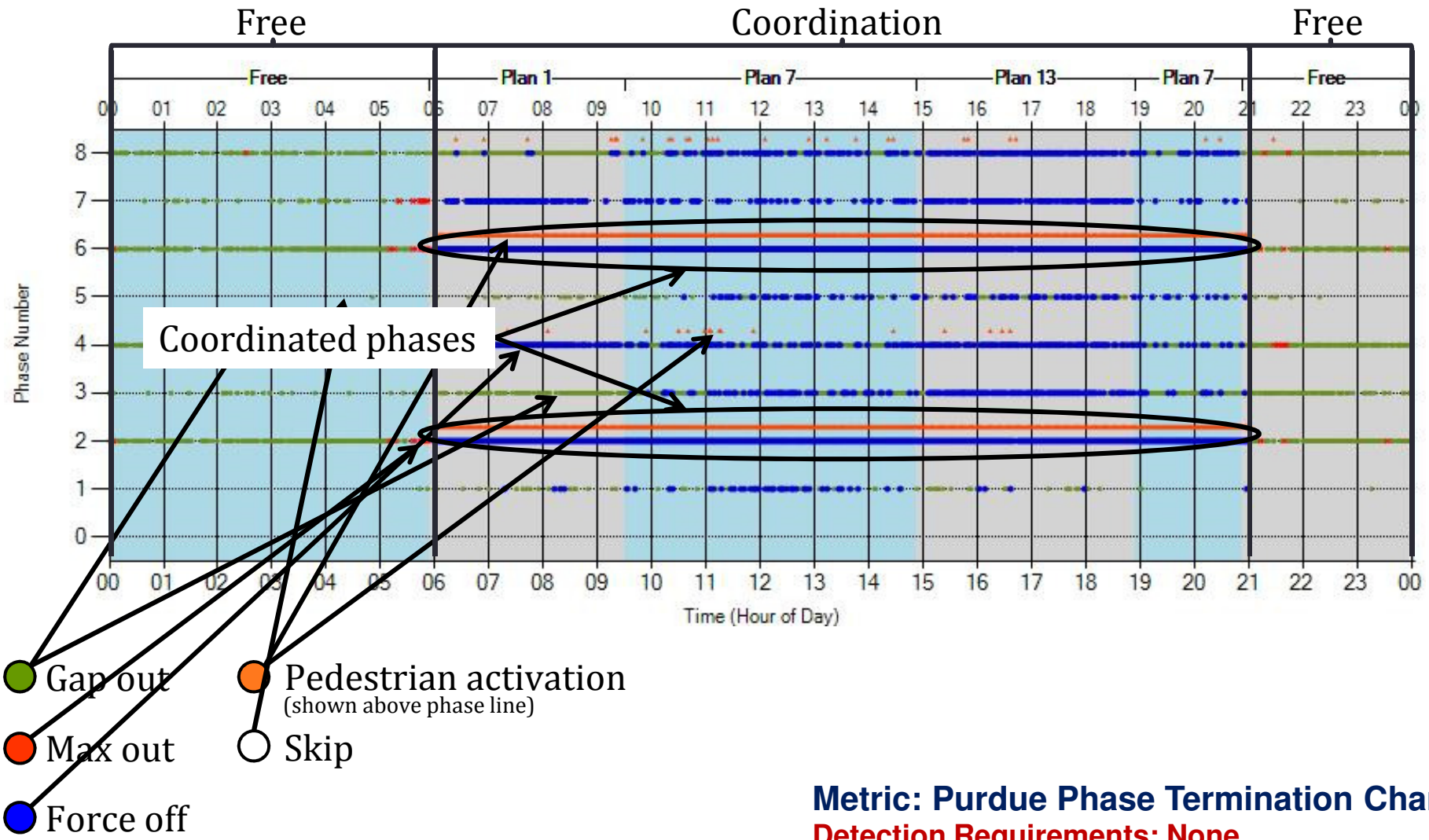
->Signal Metrics



http://udottraffic.utah.gov/signalperformancemetrics

How Phases Terminate by Time-of-Day

8-phase signal with working detection

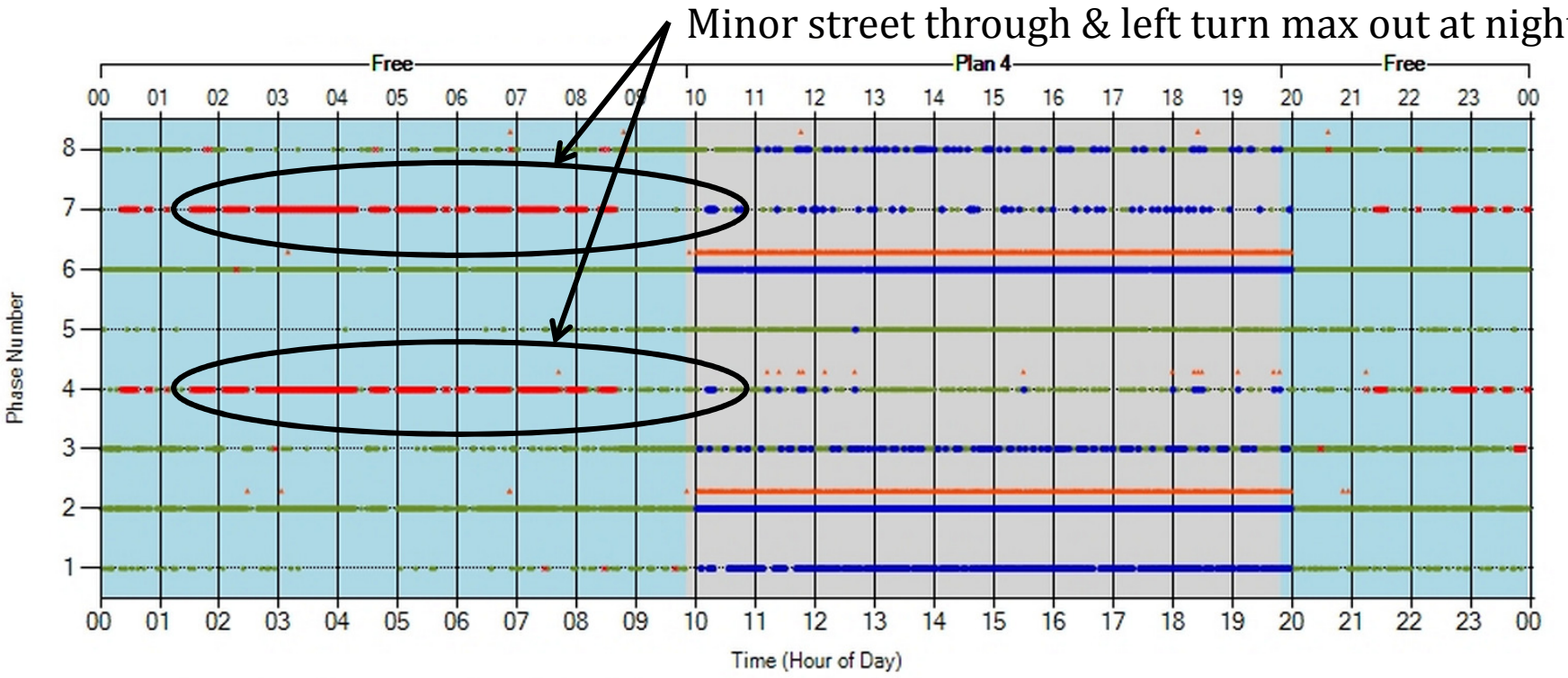


Metric: Purdue Phase Termination Chart

Detection Requirements: None

Maintenance Example: Nighttime detection problem

BEFORE: Video detection not working at night



- Gap out
- Pedestrian activation (shown above phase line)
- Max out
- Skip
- Force off

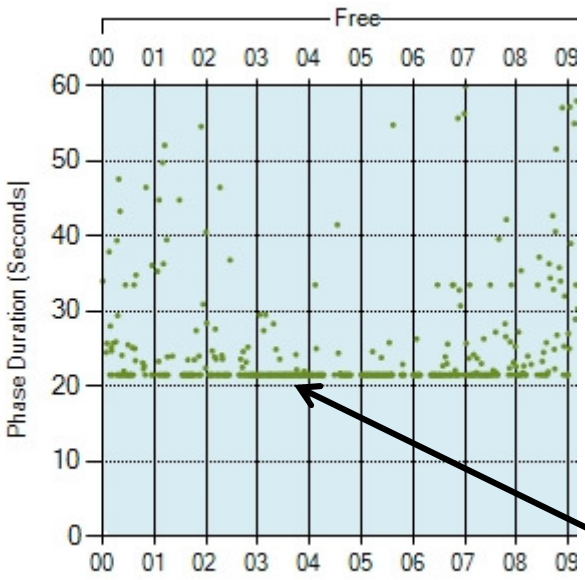
Metric: Purdue Phase Termination Chart

Detection Requirements: None

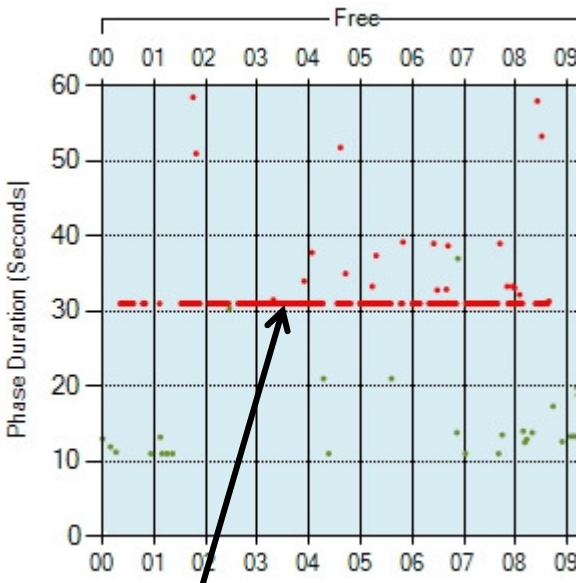
Maintenance Example: Nighttime detection problem

- BEFORE: Video detection not working at night

Major Street (Ø2)



Minor Street (Ø4)



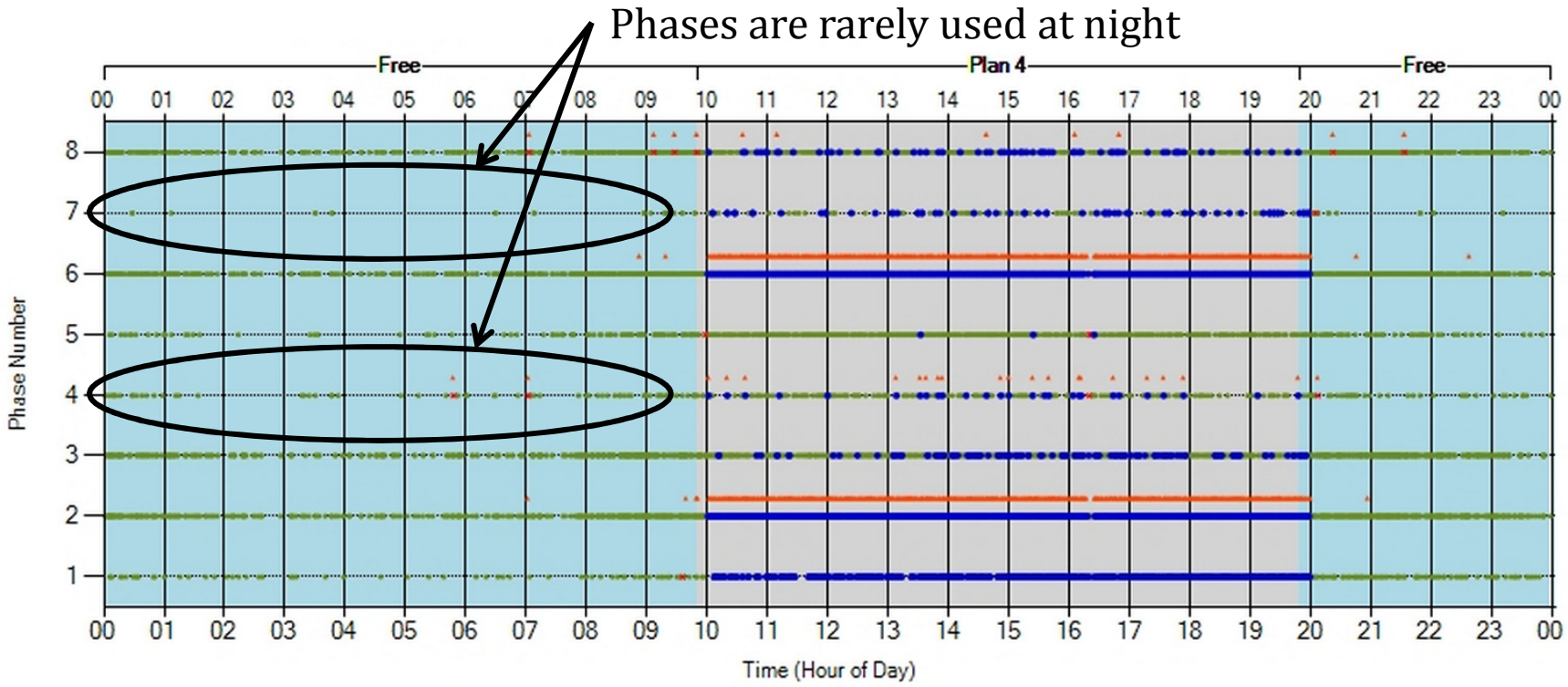
Major Street sees 20s of green and 30s of red.

- Gap out
- Max out
- Force off
- Pedestrian activation (shown above phase line)
- Skip

Metric: Split Monitor
Detection Requirements: None

Maintenance Example: Nighttime detection problem

AFTER: Detection repaired



- Gap out
- Max out
- Force off
- Pedestrian activation (shown above phase line)
- Skip

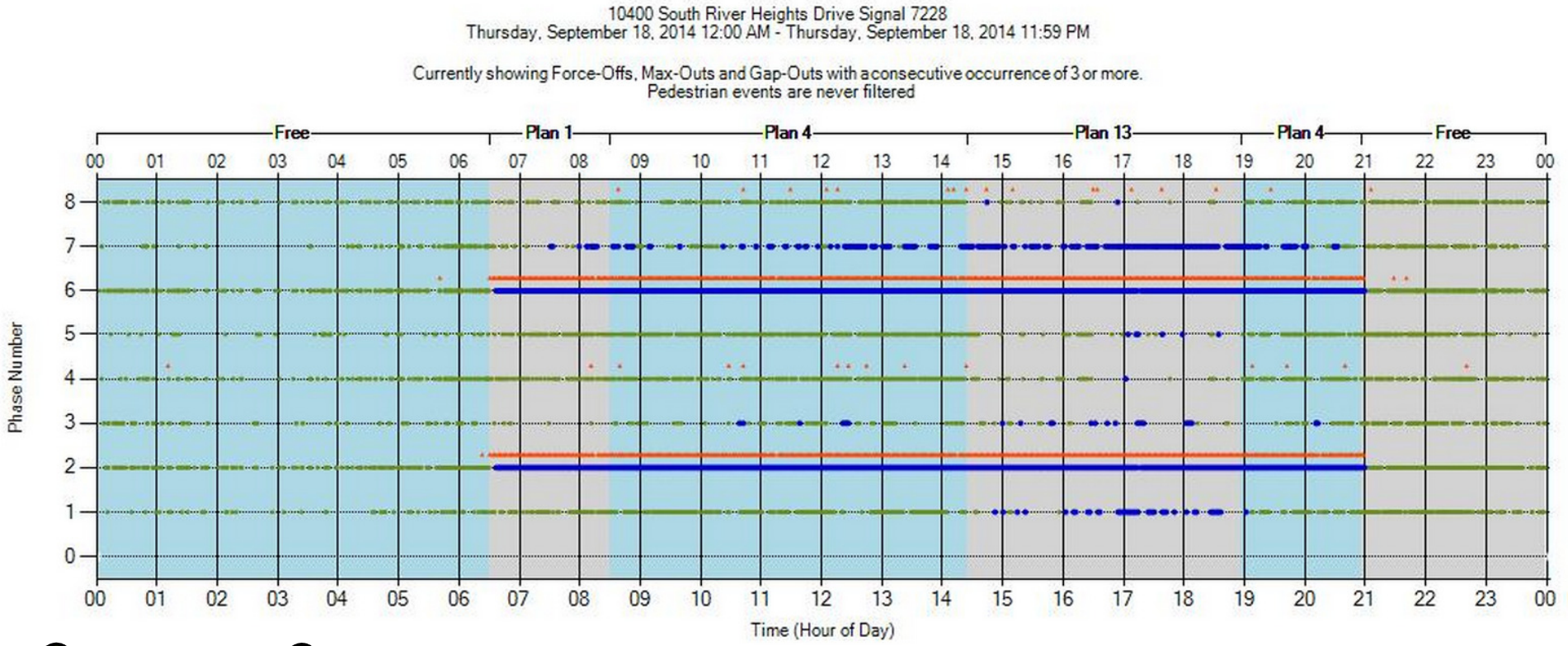
Metric: Purdue Phase Termination Chart

Detection Requirements: None

10400 South & River Heights Drive – Riverton, Utah

(Should time from phase 8 be given to phase 7?)

3 or more consecutive occurrences



- Gap out
- Pedestrian activation (shown above phase line)
- Max out
- Skip
- Force off

Metric: Purdue Phase Termination Chart

Detection Requirements: None

OVERLAND PARK KANSAS
ABOVE AND BEYOND. BY DESIGN.

Signal Performance Metrics

AASHTO Innovation Initiative

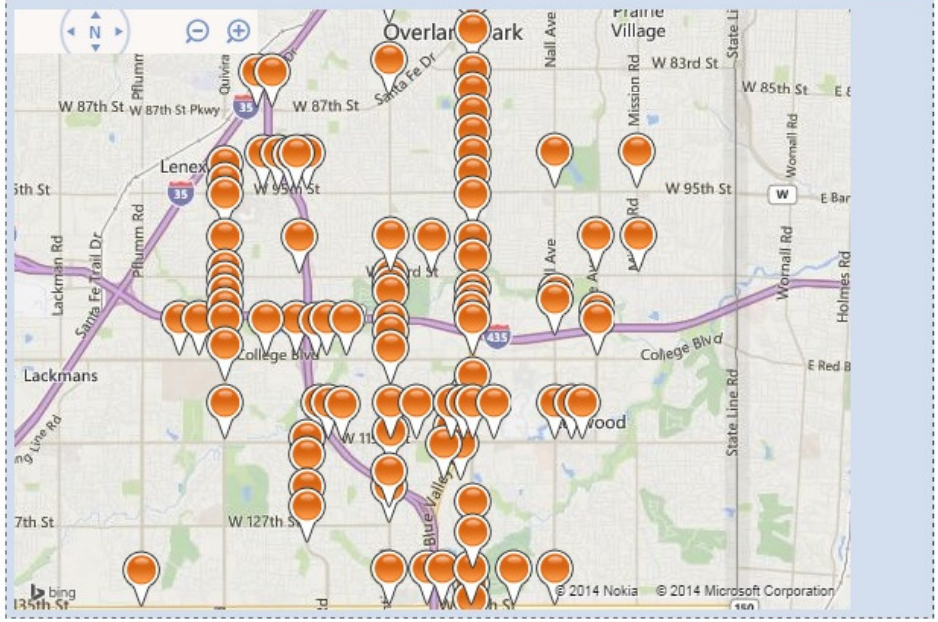
->Signal Metrics

Selected Signal
No Signal Selected

Signals
Region: All
Metric Type: All
Filter: Signal Id | Filter | Clear Filter

Signal List

Map



Metric Settings

Metric Type

Approach Delay	Purdue Phase Termination
Approach Volume	Speed
Arrivals On Red	Split Monitor
Purdue Coordination Diagram	Turning Movement Counts

Time Y Axis Maximum: 150
Volume Y Axis Maximum: 2000
Volume Bin Size: 15
Dot Size: Small
Show Plan Statistics
Show Volumes
Export Data
Upload Current Data

Dates
Start Date: 9/24/2014 ... 12:00 AM
End Date: 9/24/2014 ... 11:59 PM
Reset Date

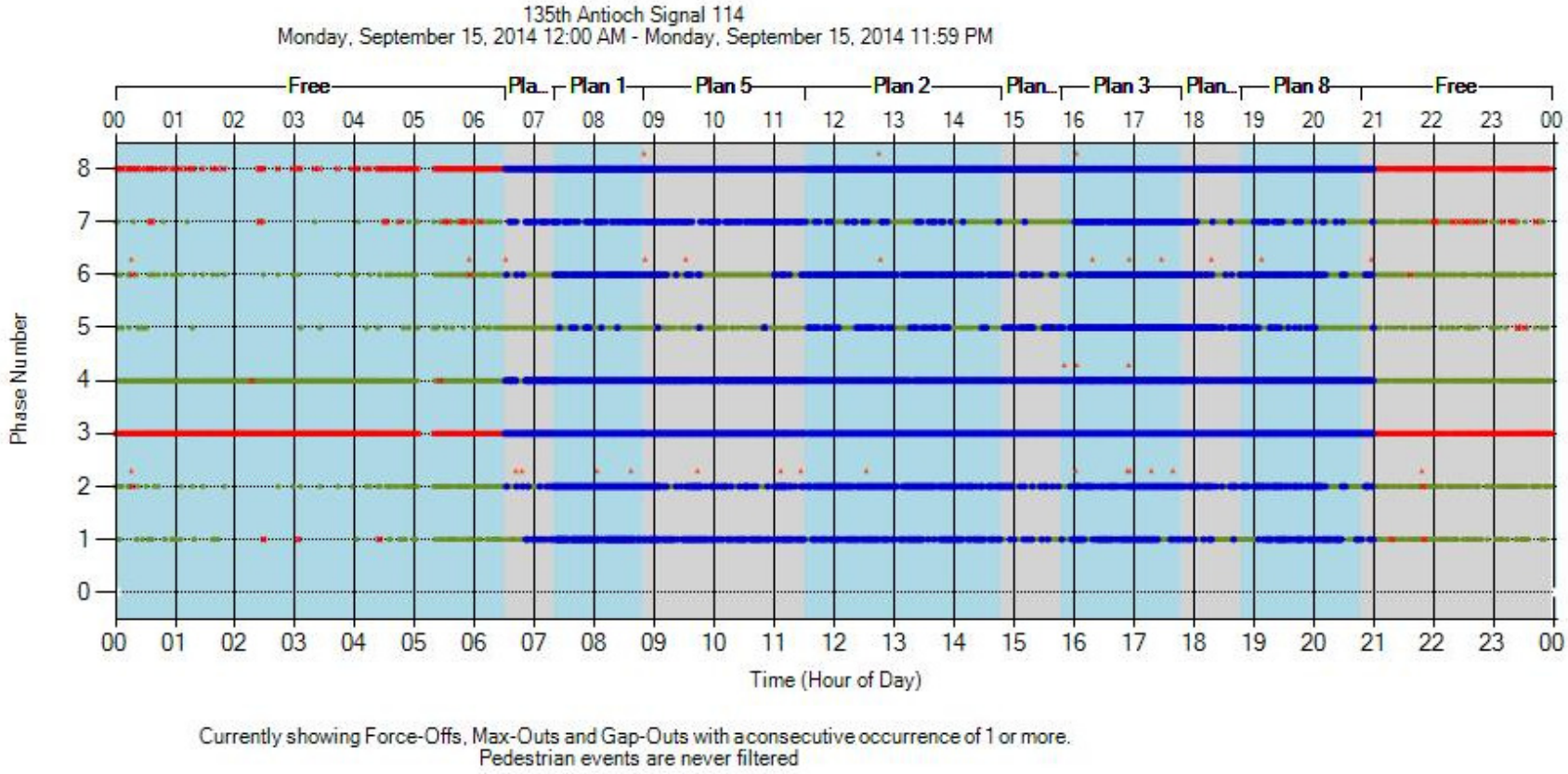
< September 2014 >

Sun	Mon	Tue	Wed	Thu	Fri	Sat
31	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	1	2	3	4
5	6	7	8	9	10	11

Overland Park, Kansas (132 intersections as of 9-24-14)

Overland Park, Kansas – 135th & Antioch

(Stuck video detection for phases 3 & 8)

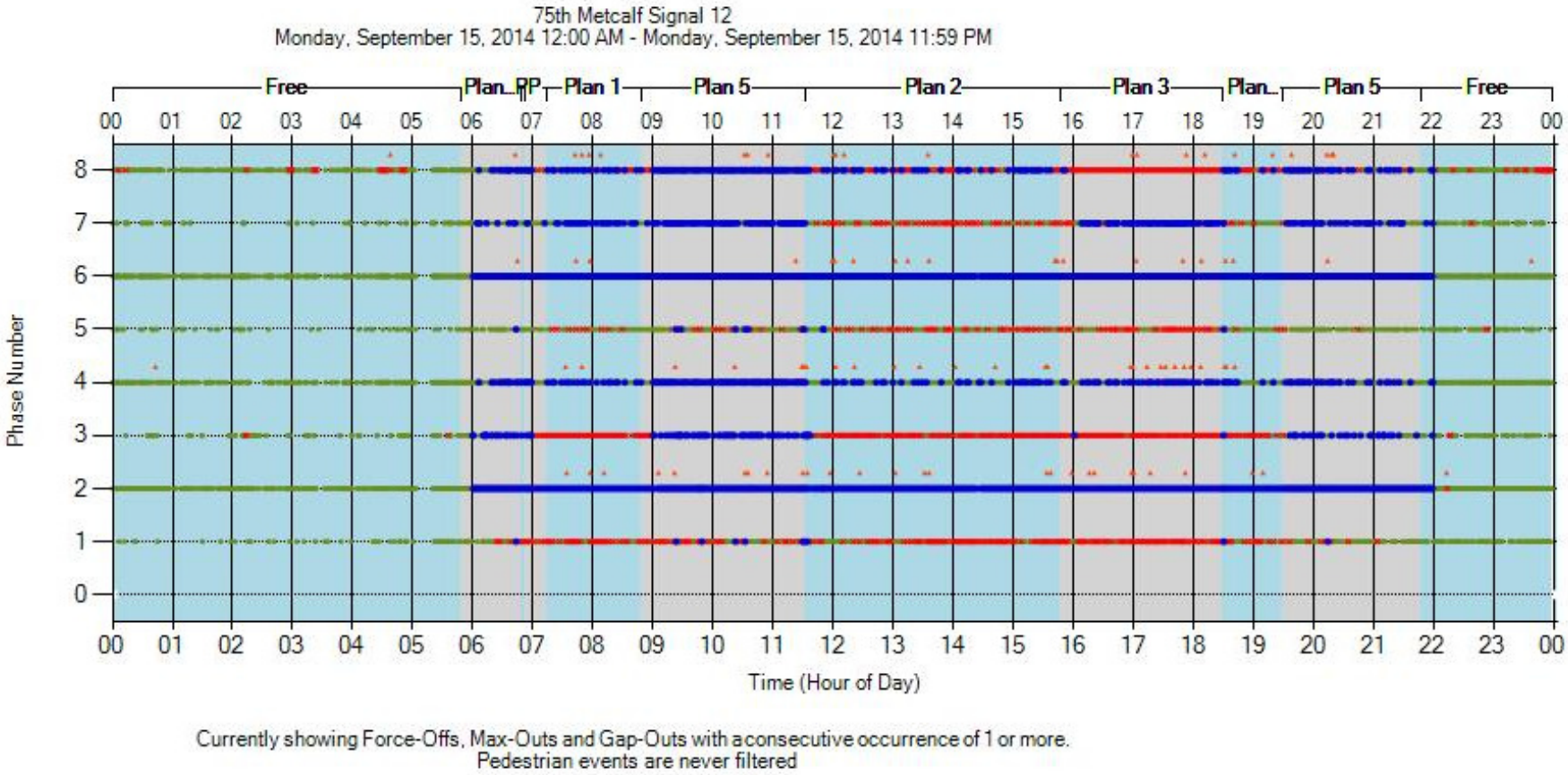


Metric: Purdue Phase Termination Chart

Detection Requirements: None

Overland Park, Kansas – 75th & Metcalf

(Phase 8 sticking on in early morning)

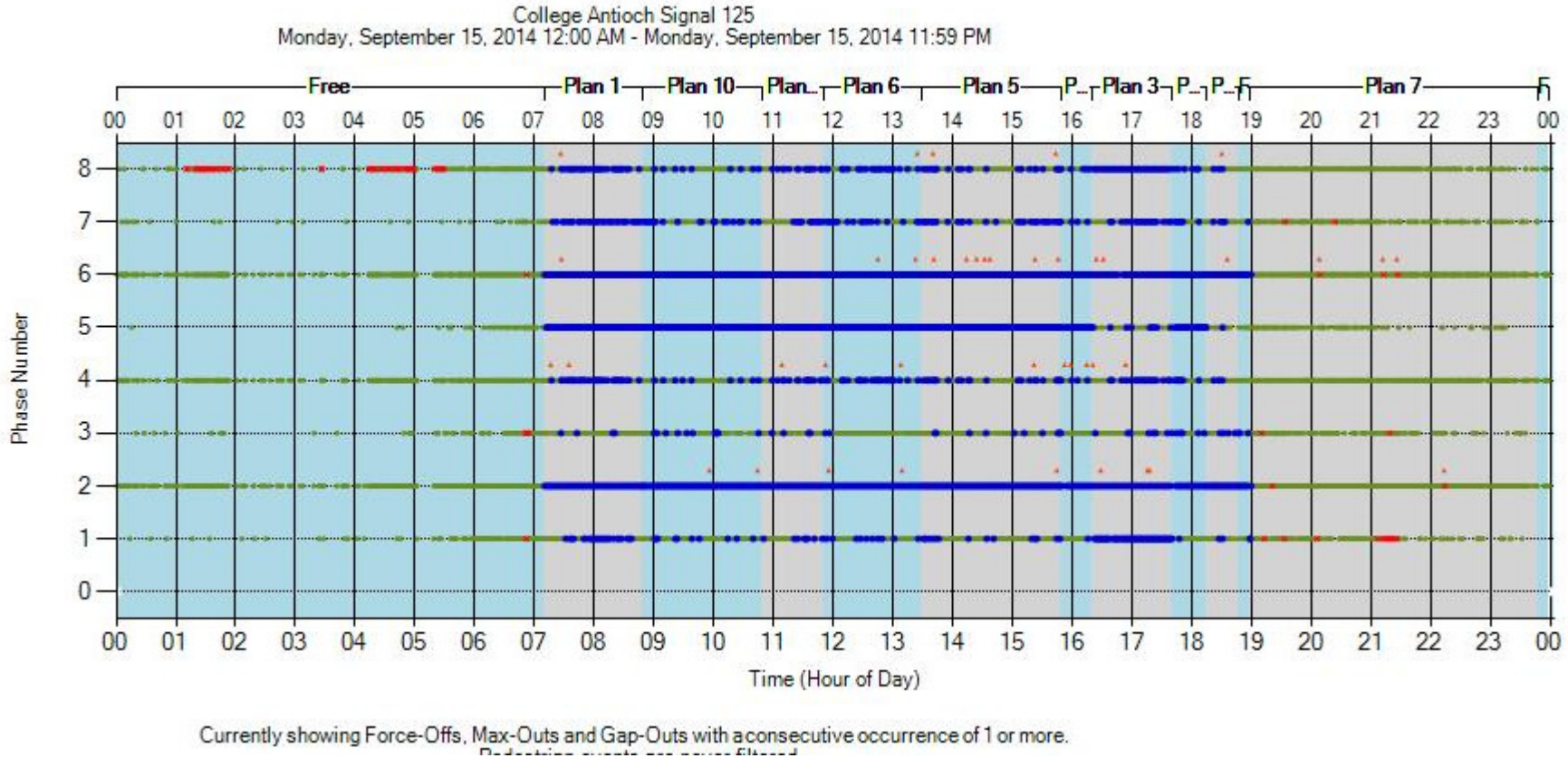


Metric: Purdue Phase Termination Chart

Detection Requirements: None

Overland Park, Kansas – College & Antioch

(Phase 8 sticking on in early morning)



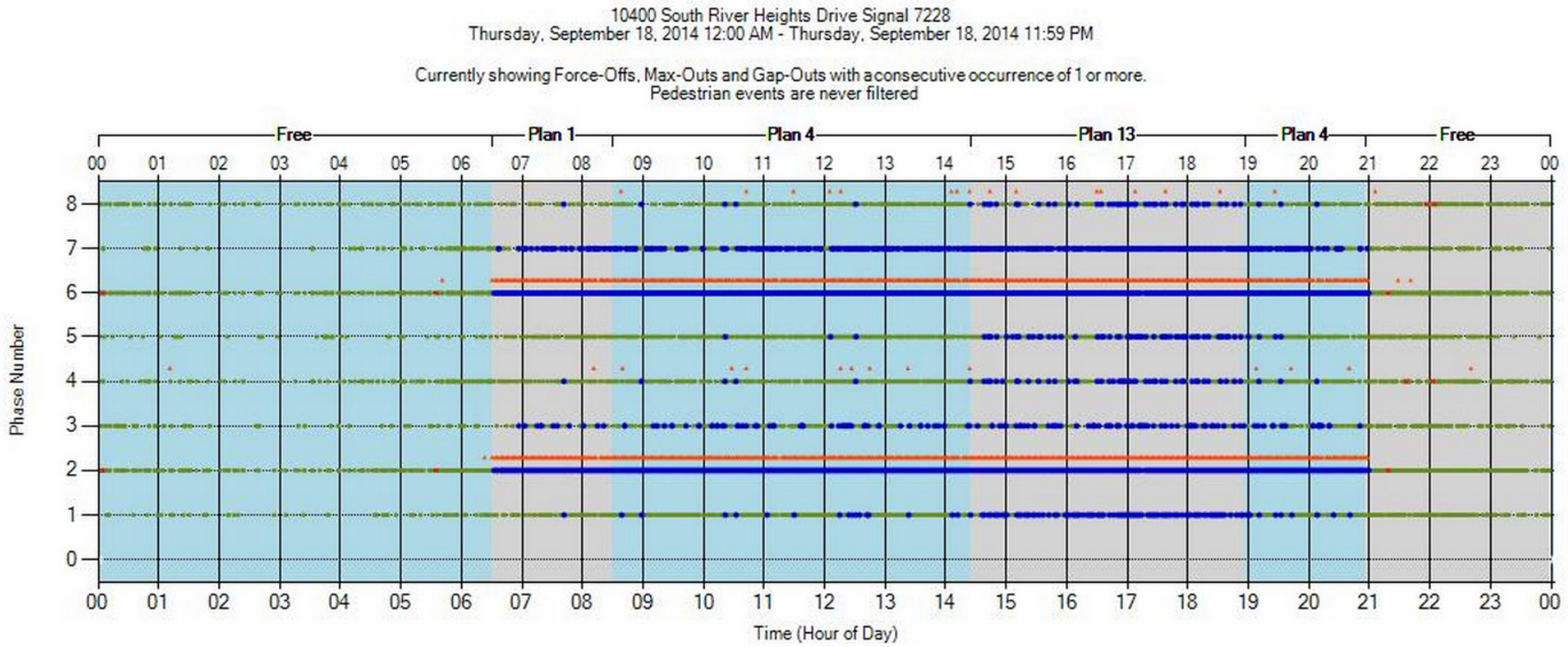
Metric: Purdue Phase Termination Chart

Detection Requirements: None

10400 South & River Heights Drive – Riverton, Utah

(Should time from phase 8 be given to phase 7?)

1 or more consecutive occurrences



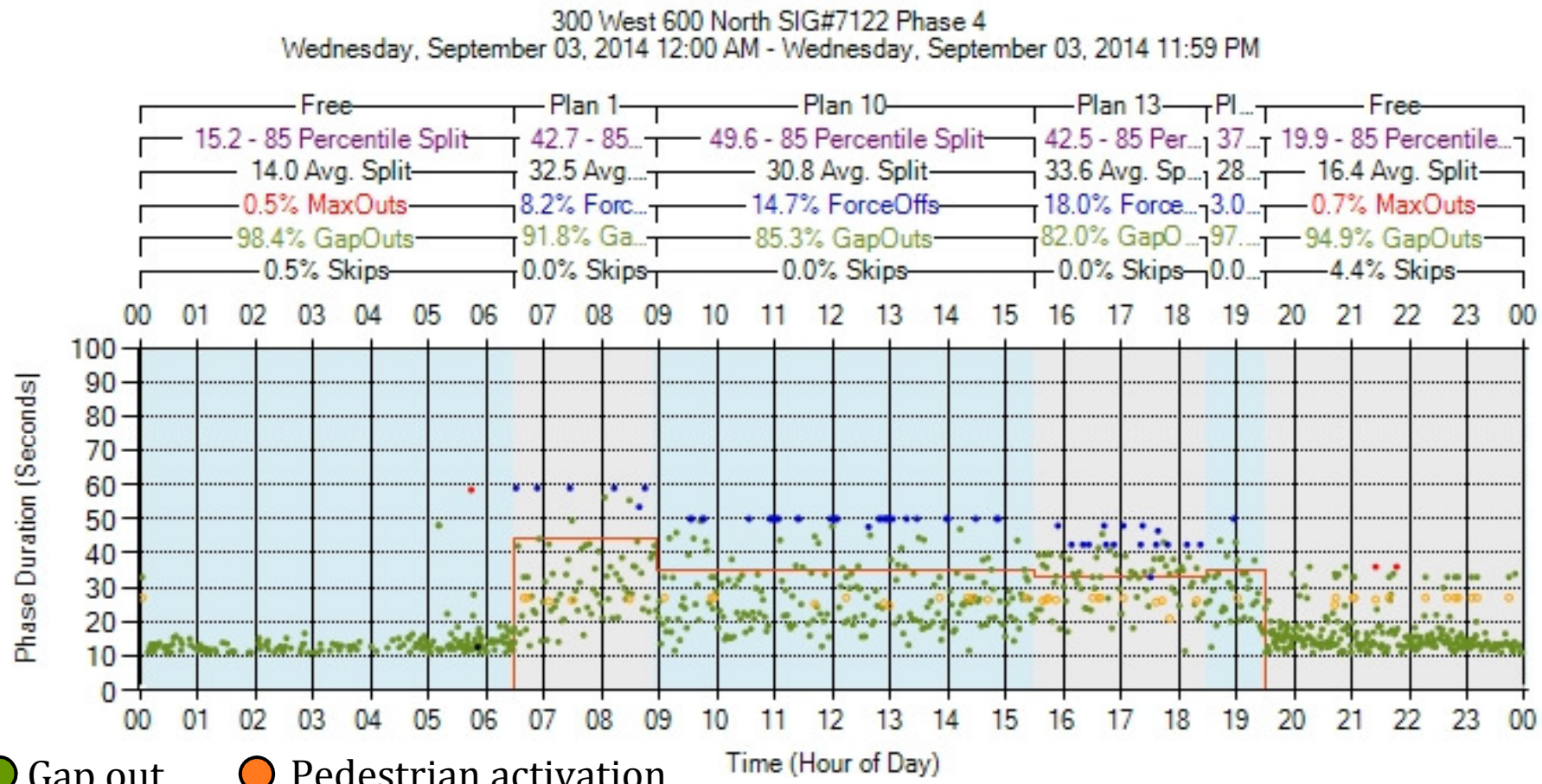
- Gap out
- Max out
- Force off
- Pedestrian activation (shown above phase line)
- Skip

Metric: Purdue Phase Termination Chart

Detection Requirements: None

Monitoring Duration of Splits by TOD

1 of 8 phases shown



Gap out

Pedestrian activation

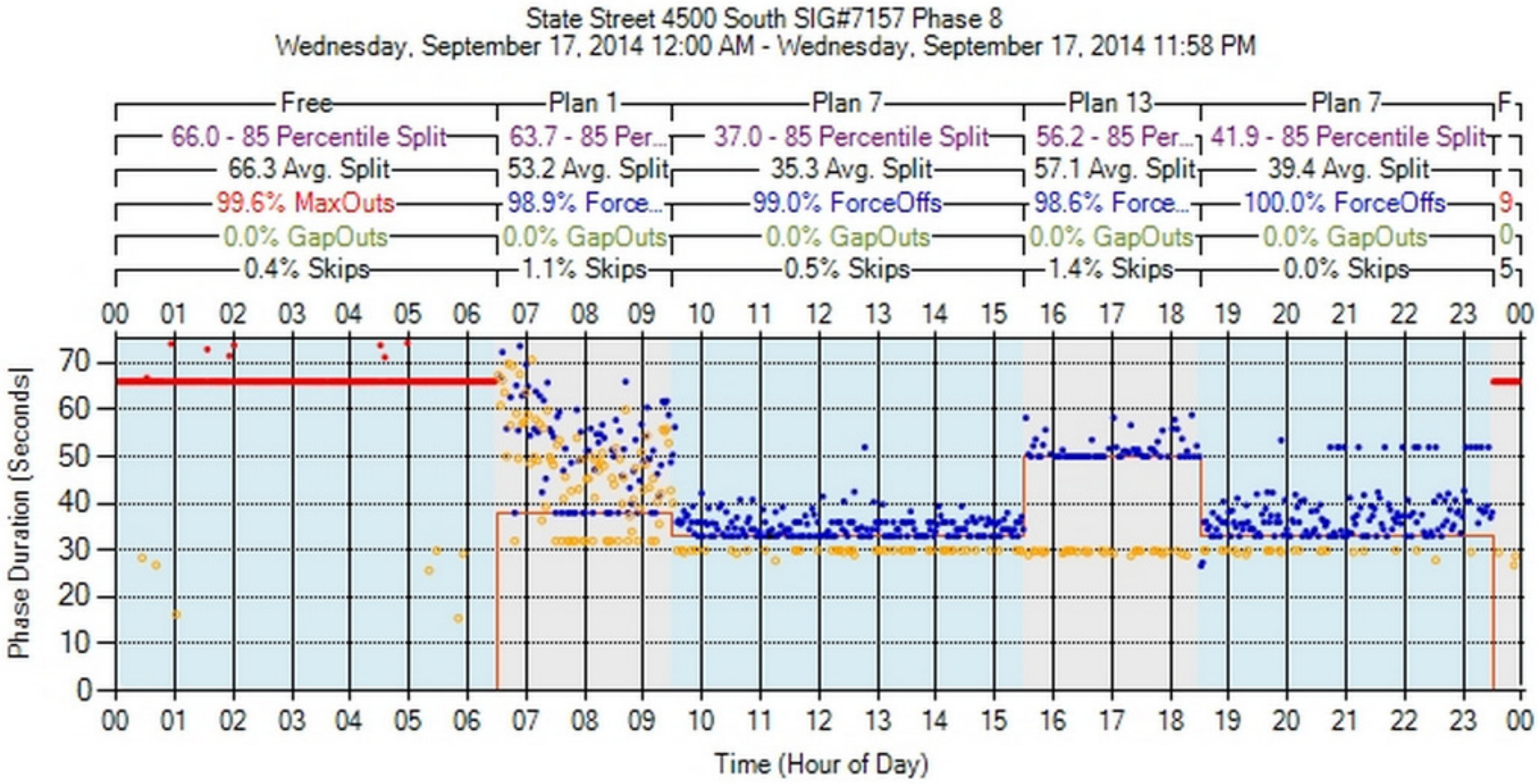
Max out

Force off

Metric: Split Monitor

Detection Requirements: None

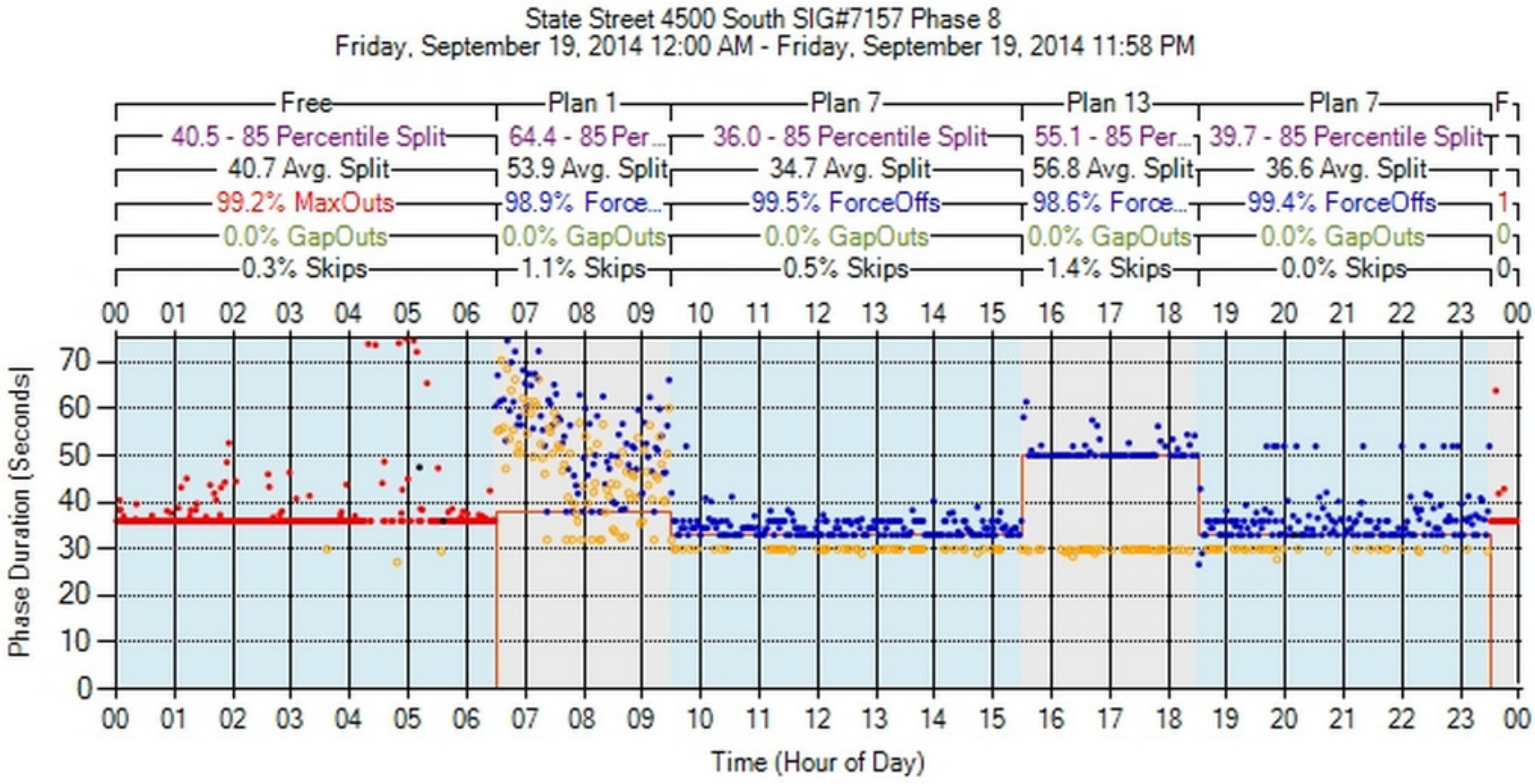
Detector gone bad. Long Max1.



Metric: Split Monitor

Detection Requirements: None

Reduced Max1 to historical values until detection is fixed.

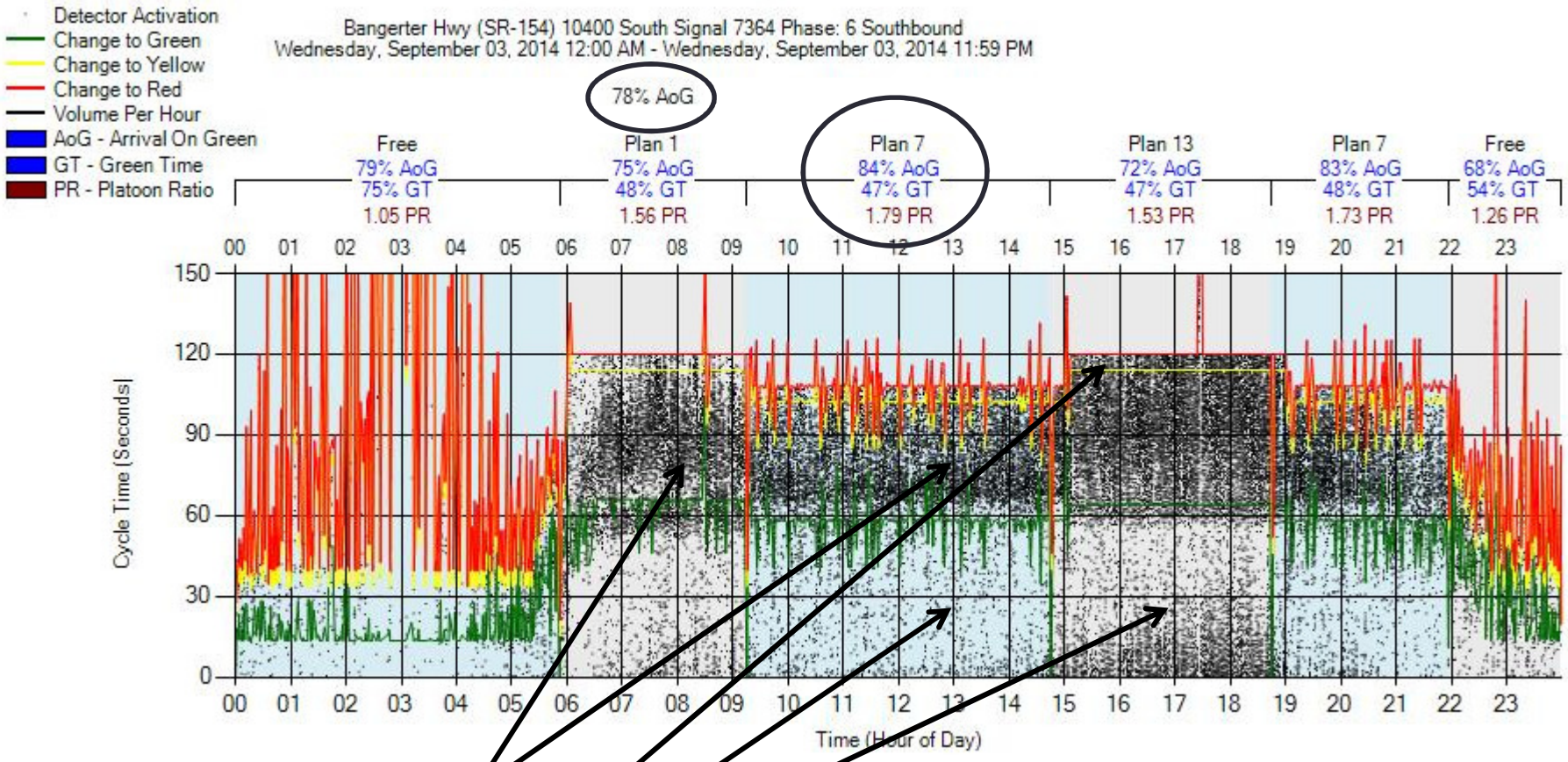


Metric: Split Monitor

Detection Requirements: None

Coordination Optimization Example: Progression Quality

One approach shown



Vehicles arrive on green

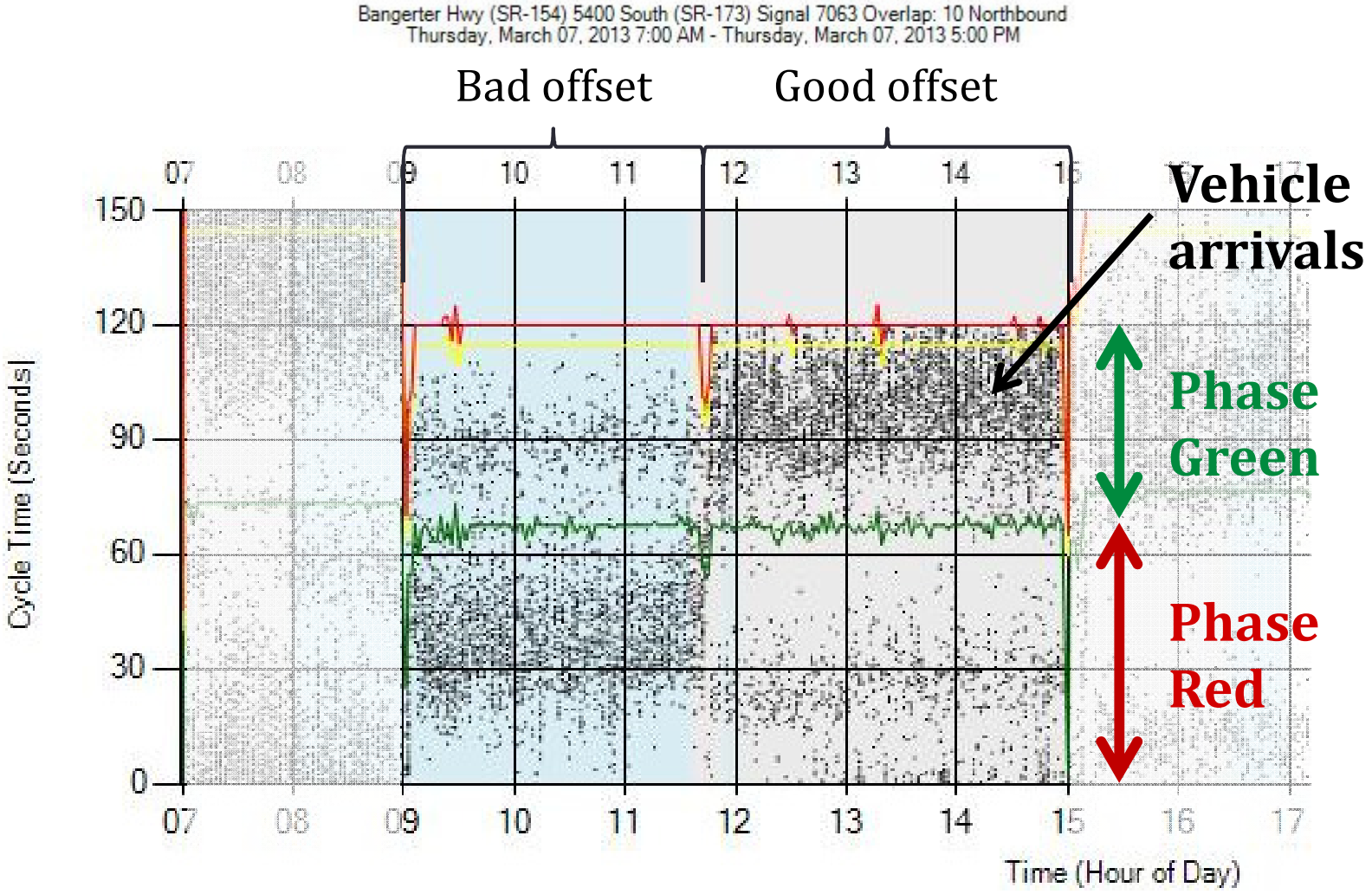
Vehicles arrive on yellow

Vehicles arrive on red

Metric: Purdue Coordination Diagram

Detection Requirements: Advance Counters

Optimization Example: Progression Quality

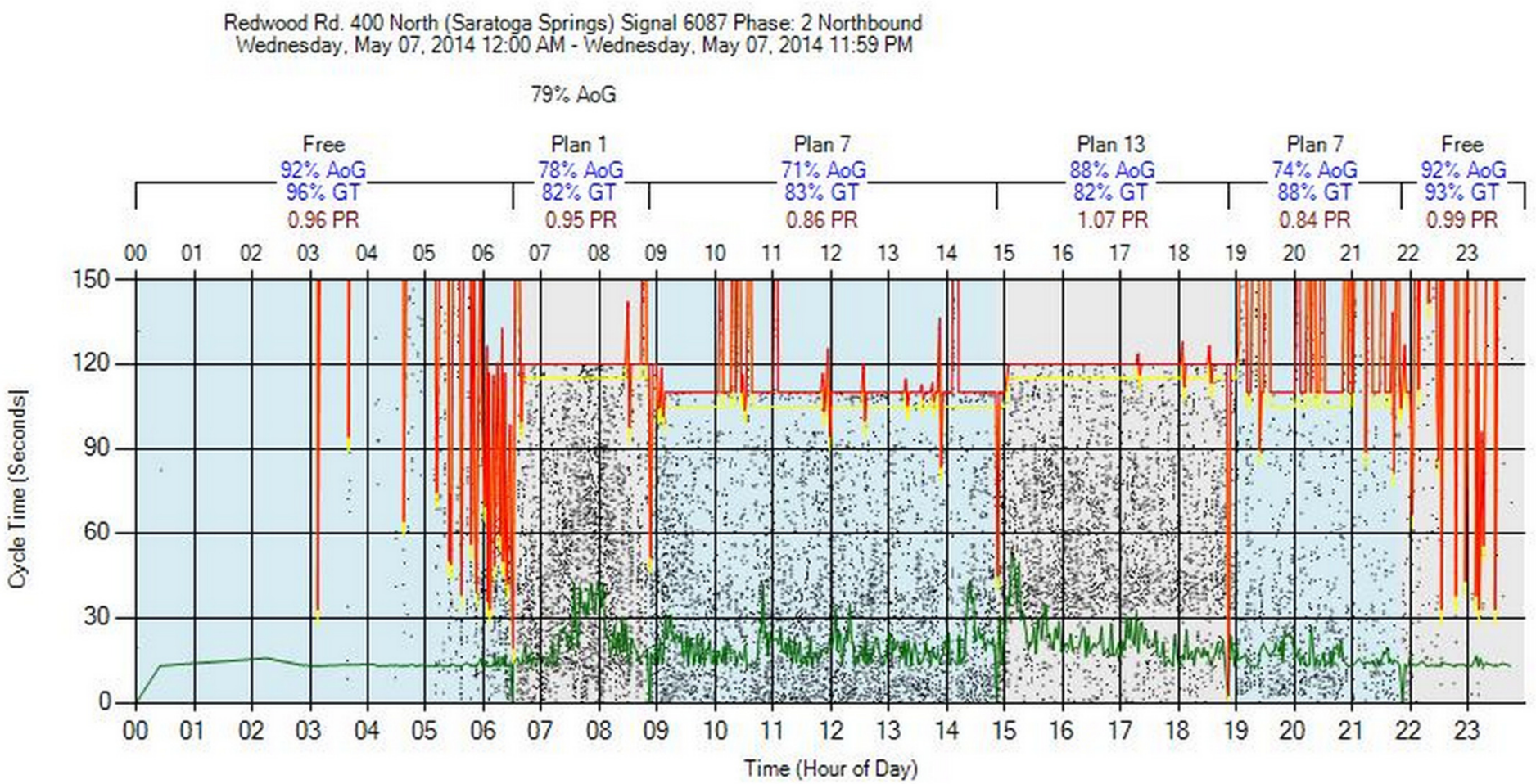


Metric: Purdue Coordination Diagram

Detection Requirements: Advance Counters

Full Cycle: Offpeak Plan 7(Before)

Redwood Rd & 400 North – Saratoga Springs – May 7, 2014 - Northbound

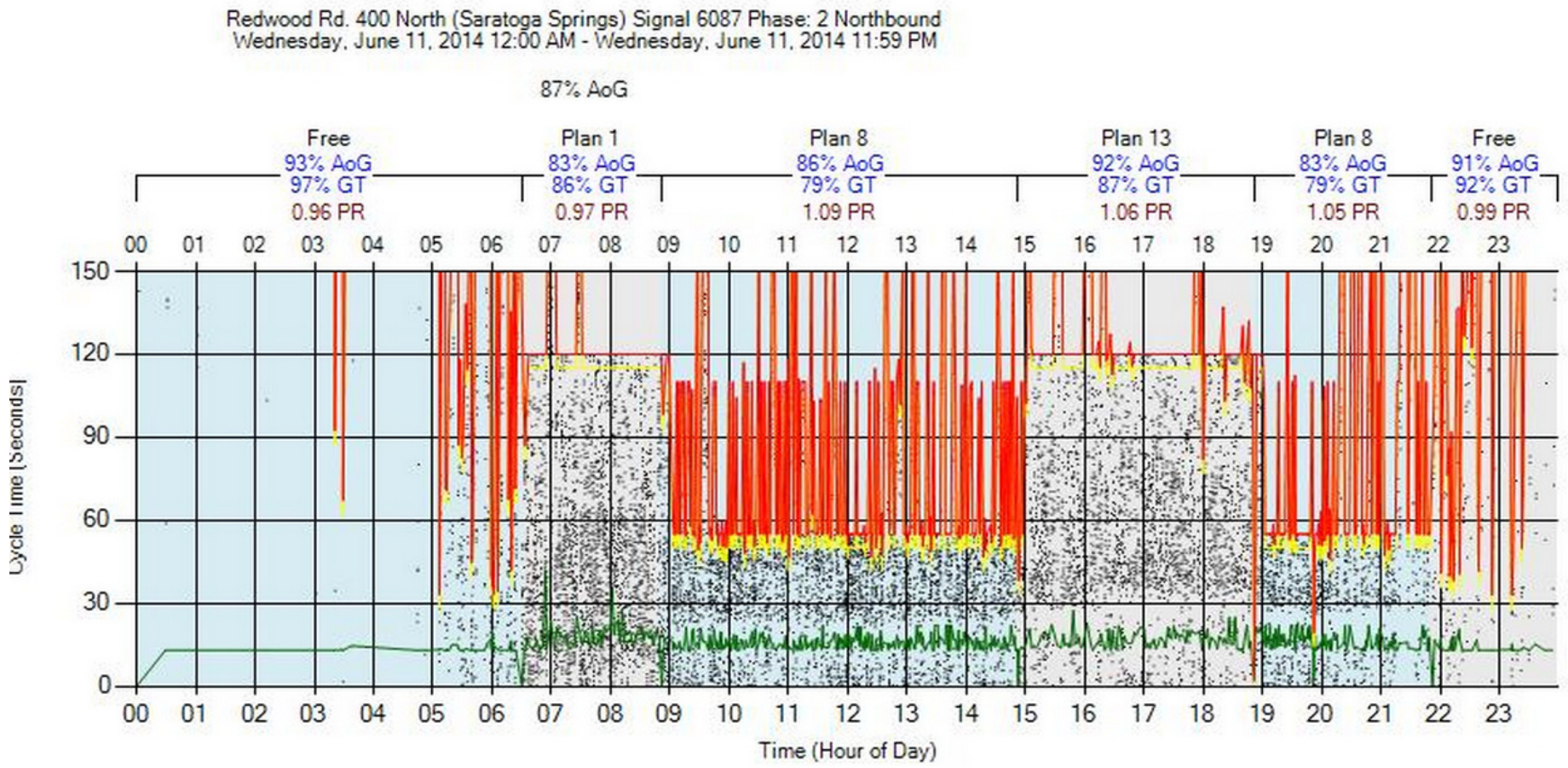


Metric: Purdue Coordination Diagram

Detection Requirements: Advance Counters

Double Cycle: Offpeak Plan 8 (After)

Redwood Rd & 400 North – Saratoga Springs – June 11, 2014 - Northbound

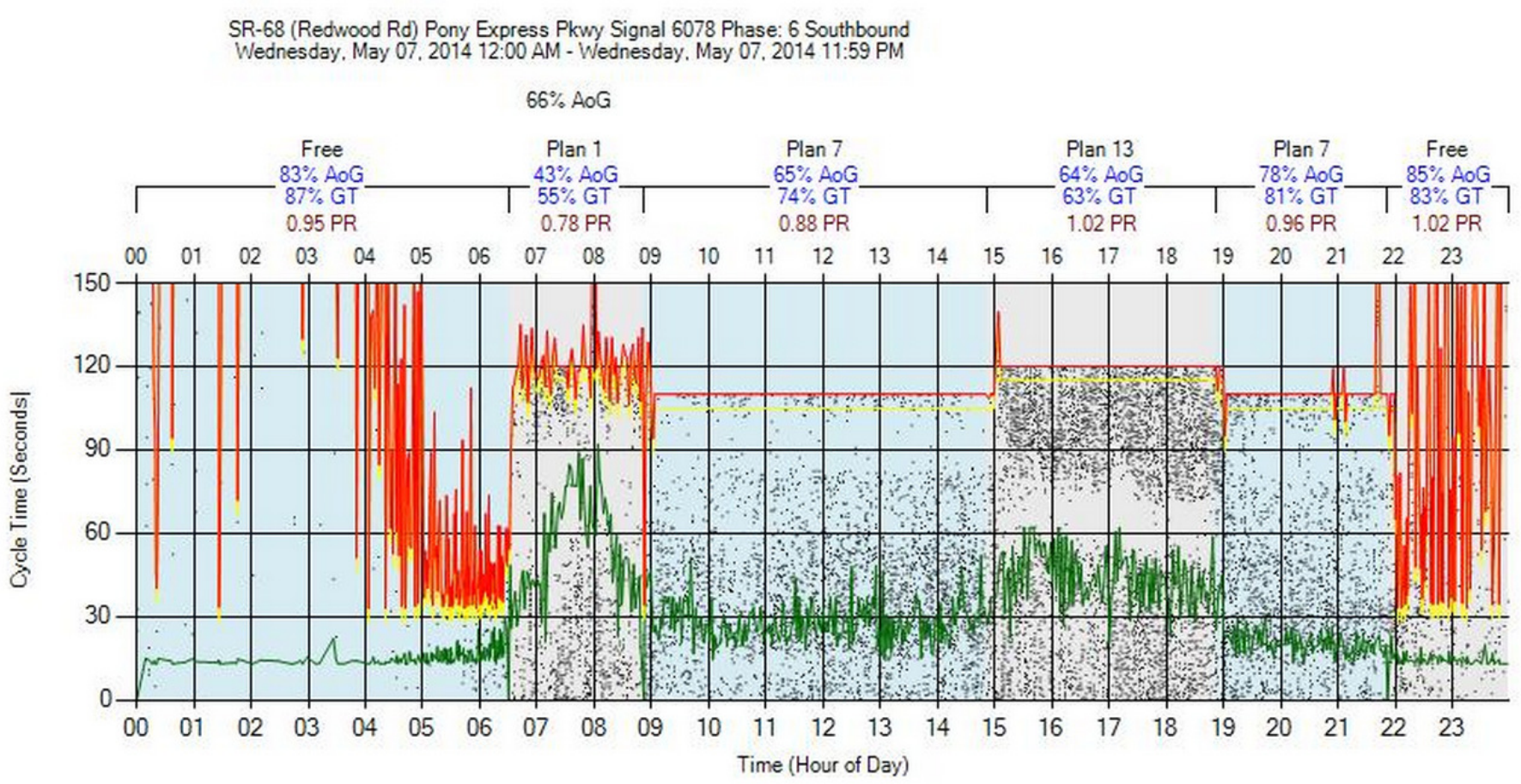


Metric: Purdue Coordination Diagram

Detection Requirements: Advance Counters

Full Cycle: Offpeak Plan 7(Before)

Redwood Rd & Pony Express – Saratoga Springs – May 7, 2014 - Southbound

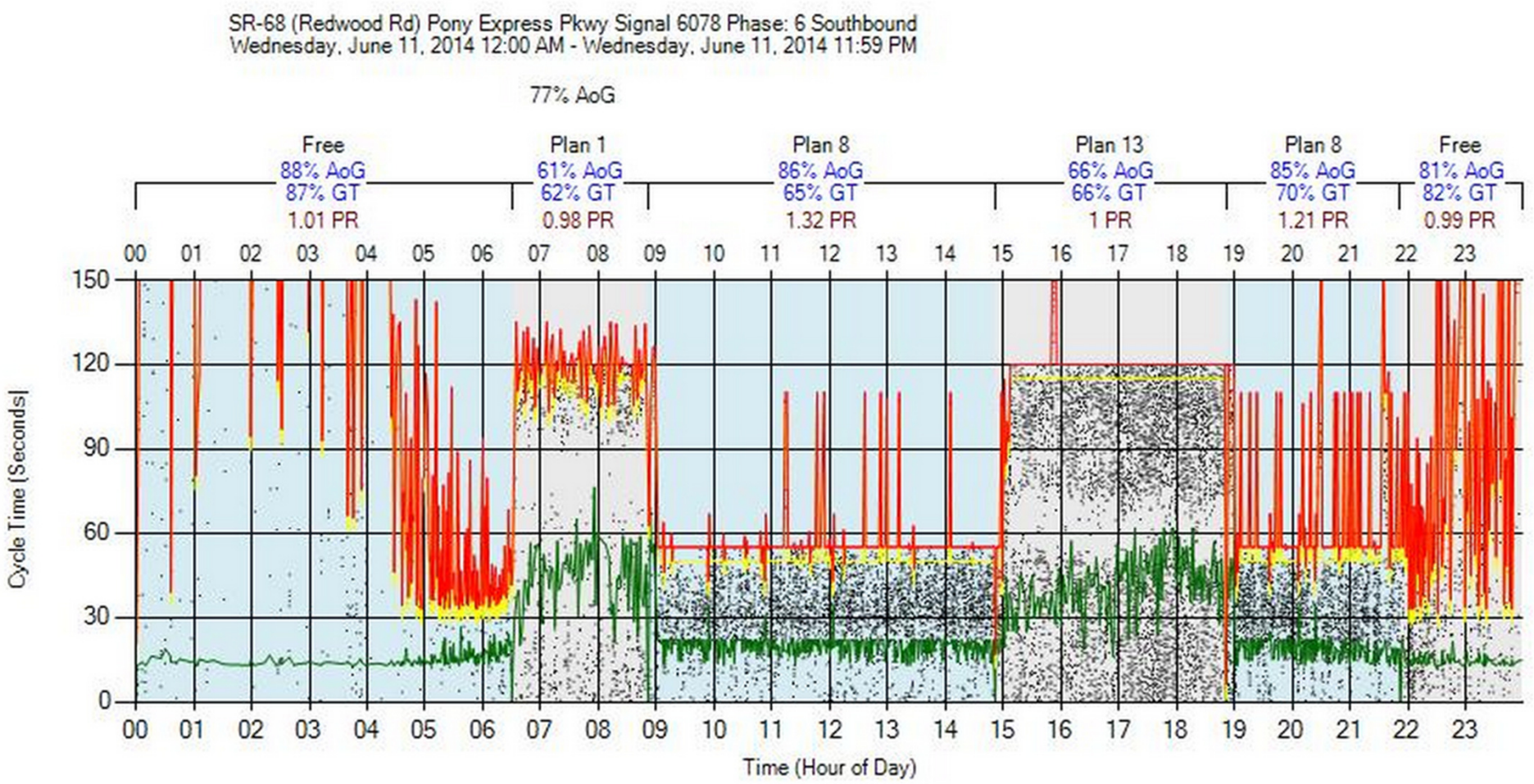


Metric: Purdue Coordination Diagram

Detection Requirements: Advance Counters

Double Cycle: Offpeak Plan 8 (After)

Redwood Rd & Pony Express – Saratoga Springs – June 11, 2014 - Southbound

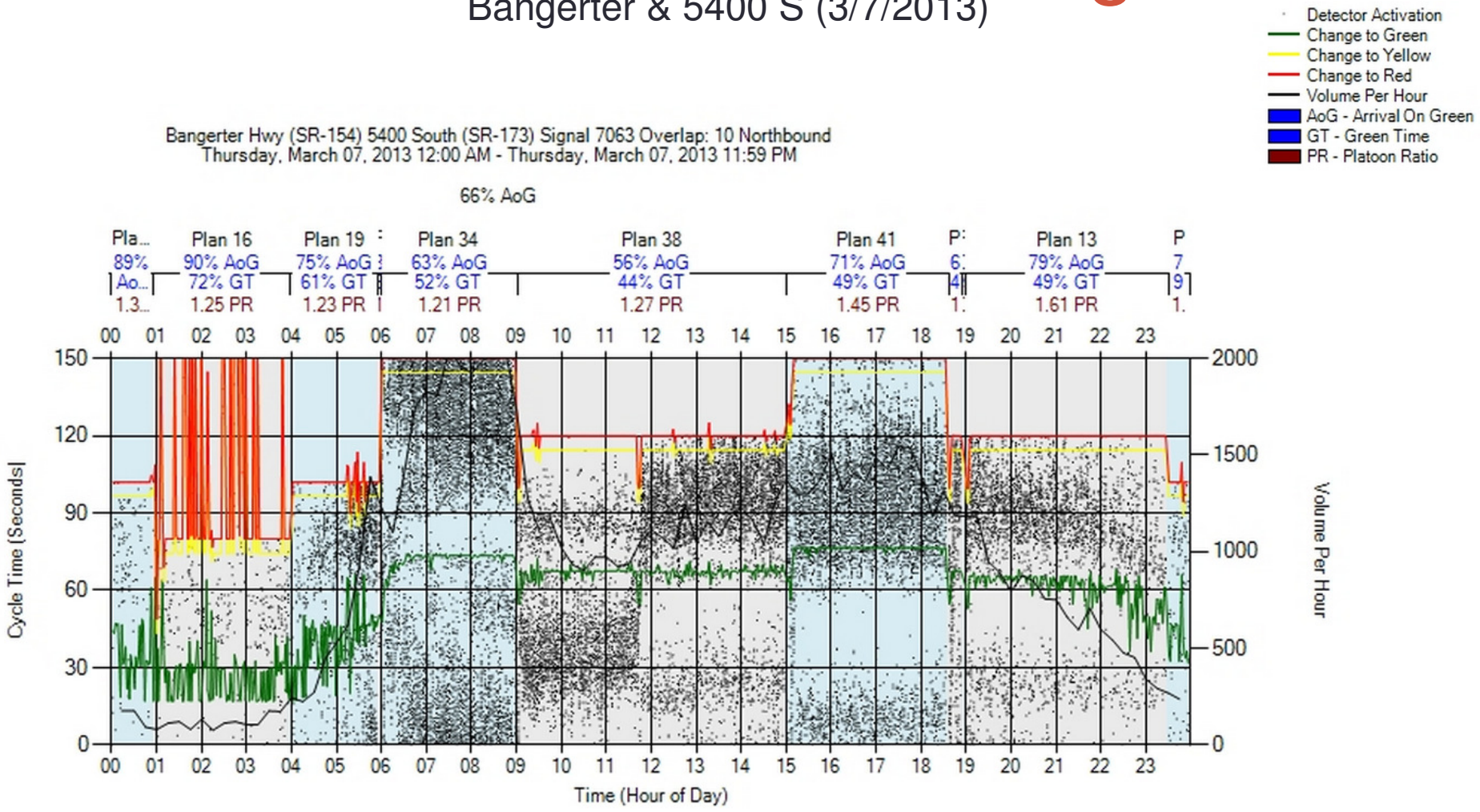


Metric: Purdue Coordination Diagram

Detection Requirements: Advance Counters

Purdue Coordination Diagram

Bangerter & 5400 S (3/7/2013)

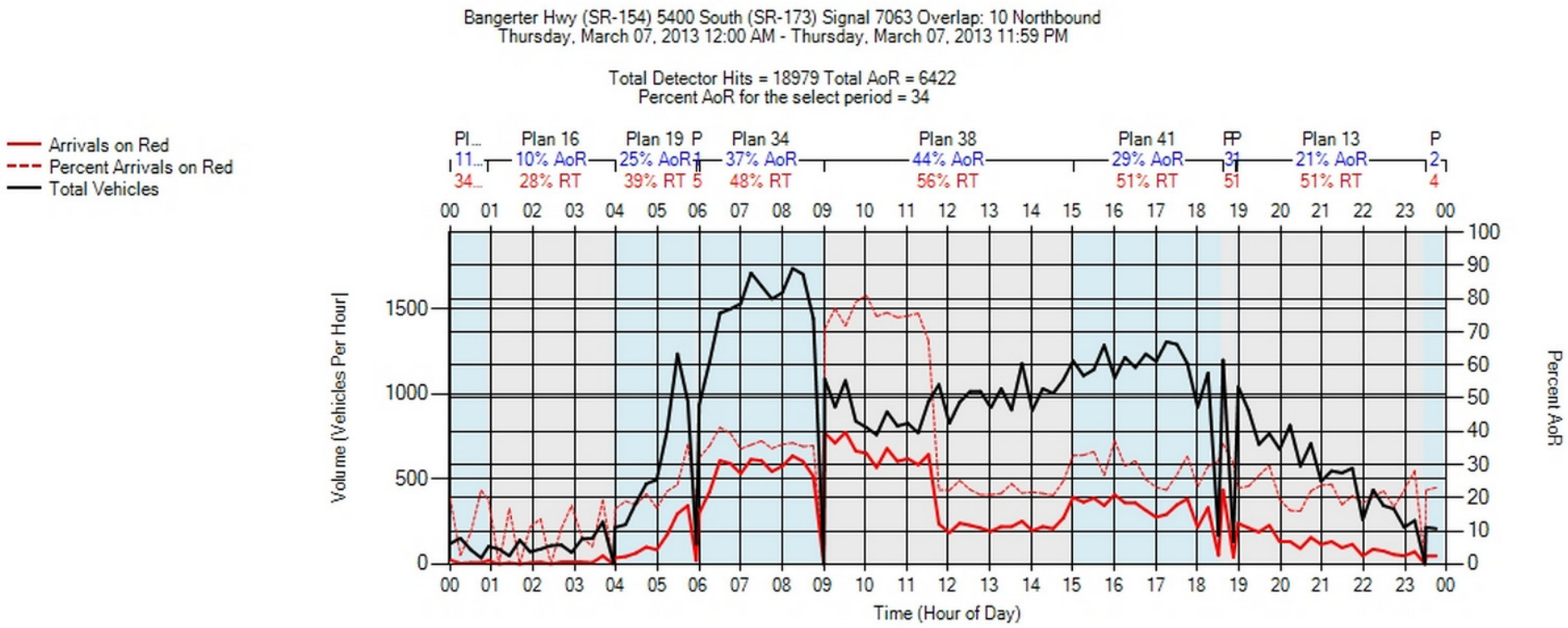


Metric: Purdue Coordination Diagram

Detection Requirements: Advance Counters

Arrivals on Red

Bangerter & 5400 S NB (3/7/2013)

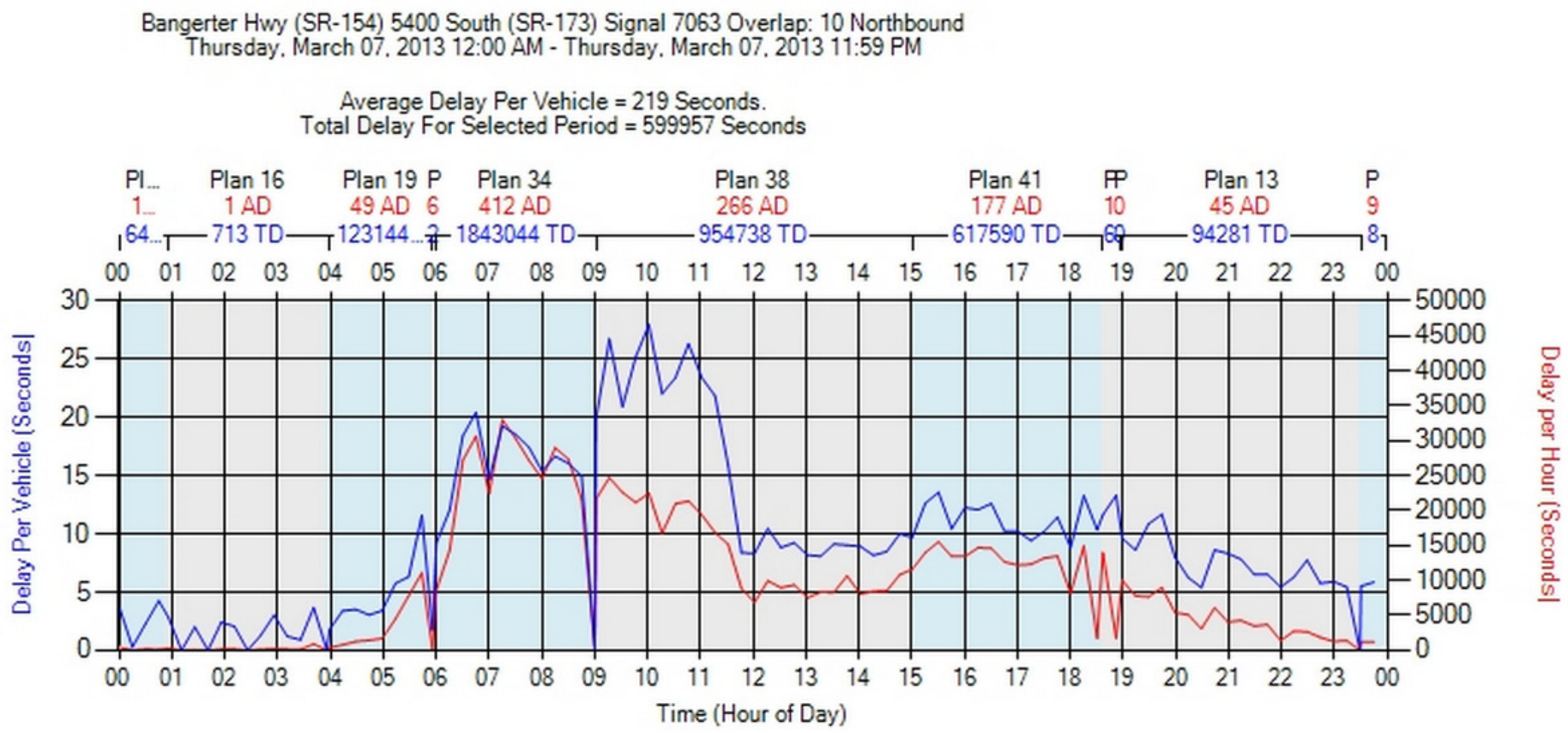


Metric: Arrivals on Red

Detection Requirements: Advance Counters

Simplified Approach Delay

Bangerter & 5400 S NB (3/7/2013)



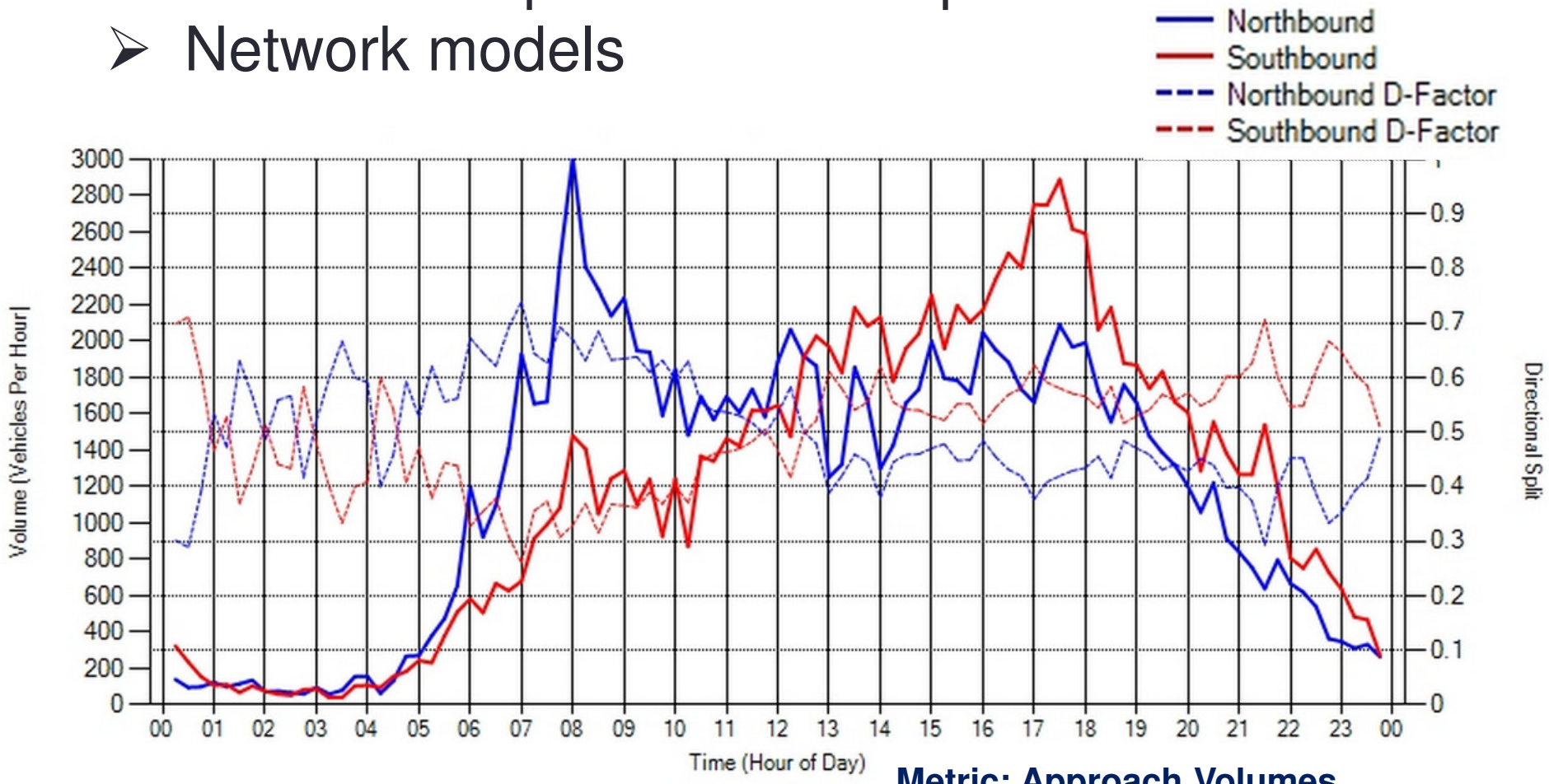
Simplified Approach Delay. Displays time between detector activation during the red phase and when the phase turns green. Does NOT account for start up delay, deceleration, or queue length that exceeds the detection zone.

Metric: Approach Delay

Detection Requirements: Advance Counters

Approach Volumes

- When to take a lane for maintenance
- Directional splits for offset optimization
- Network models

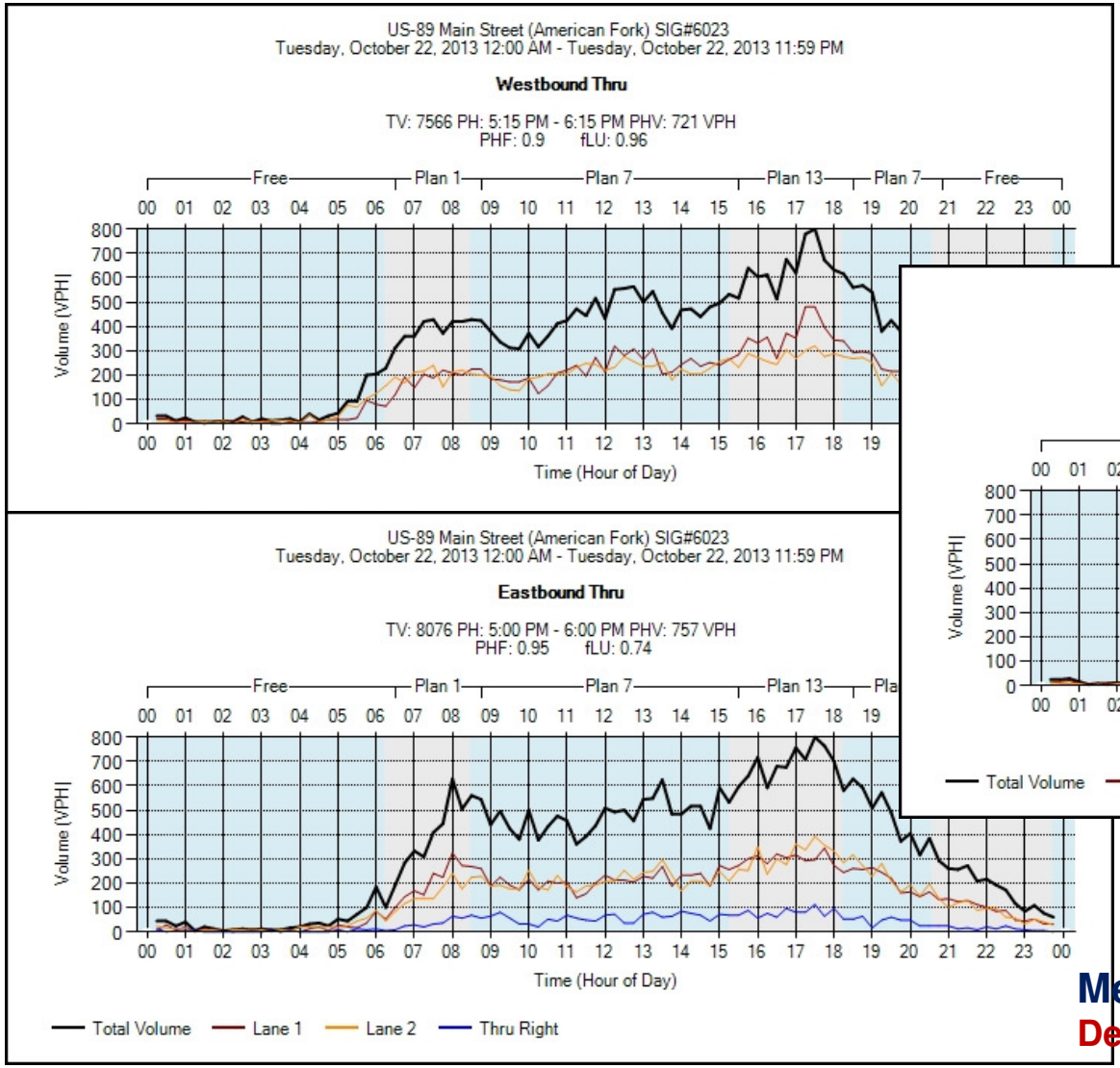


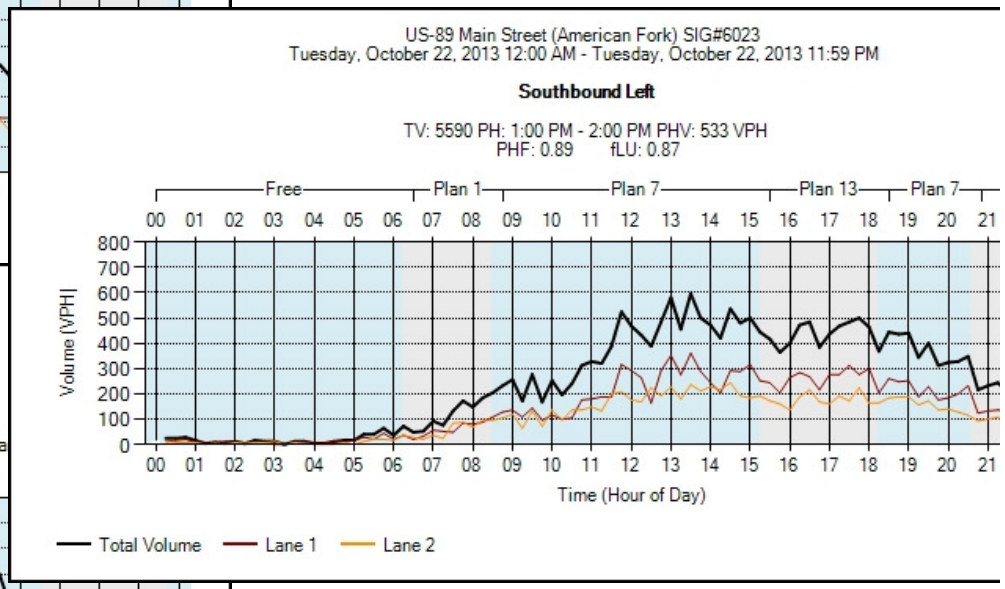
Metric: Approach Volumes

Detection Requirements: Advance Counters

Lane-by-Lane Volume Counts

Use for traffic studies, models, adjust splits, coordination balance



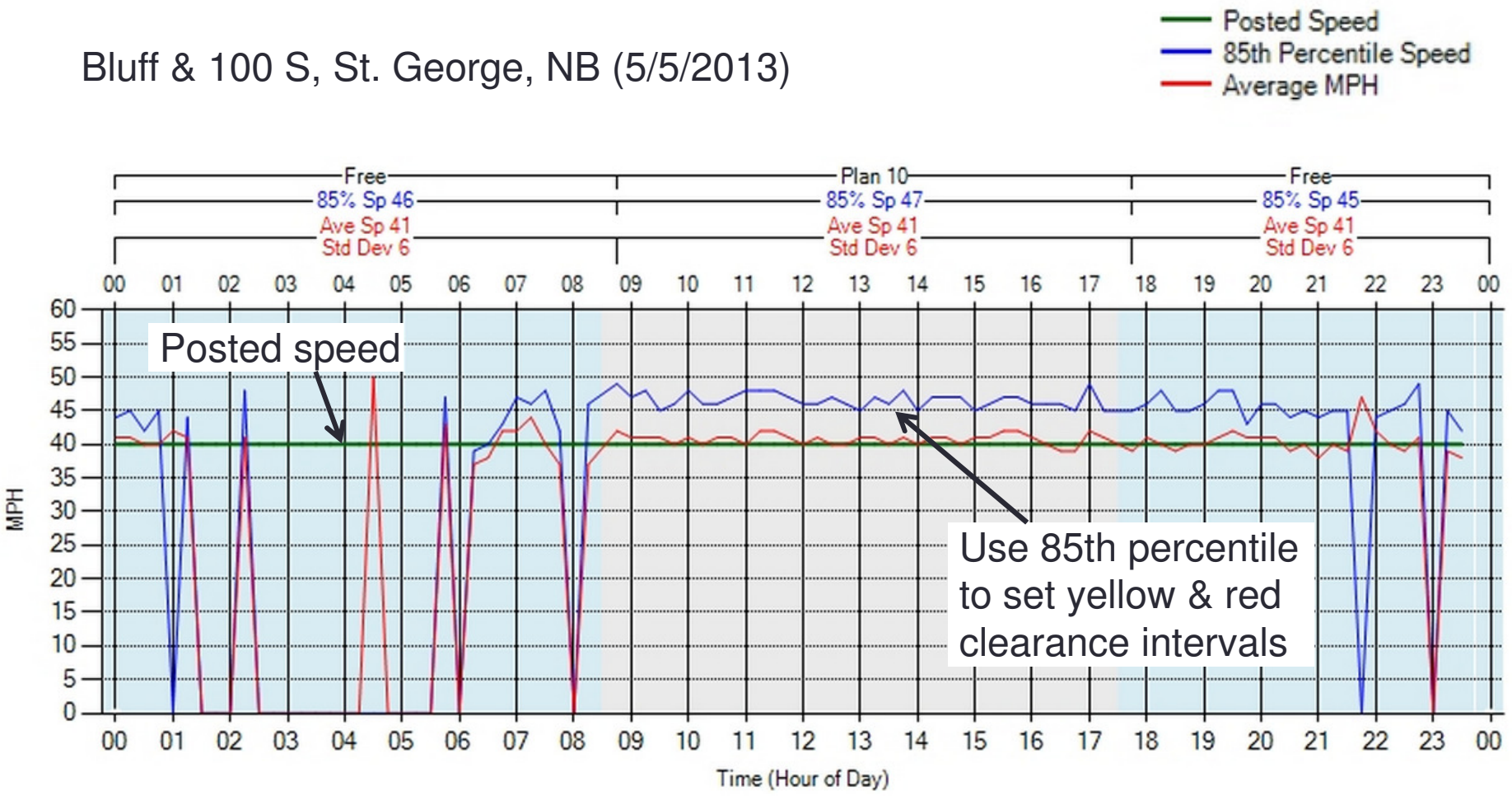


Metric: Turning Movement Counts

Detection Requirements: Stop Bar Counters

Approach Speeds

Bluff & 100 S, St. George, NB (5/5/2013)

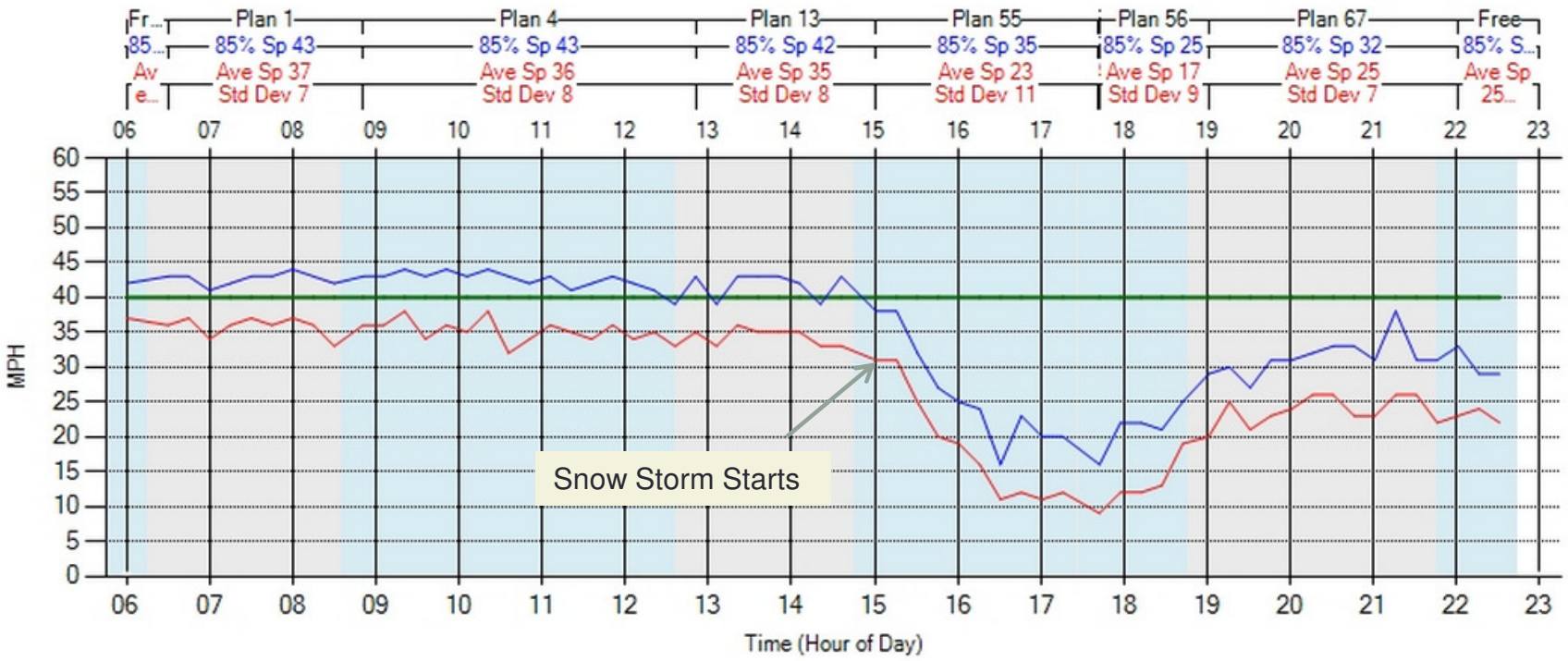


Metric: Approach Speeds

Detection Requirements: Wavetronix Advance Radar

Operations & Traffic Study Example:

Vehicle Speeds at Intersections



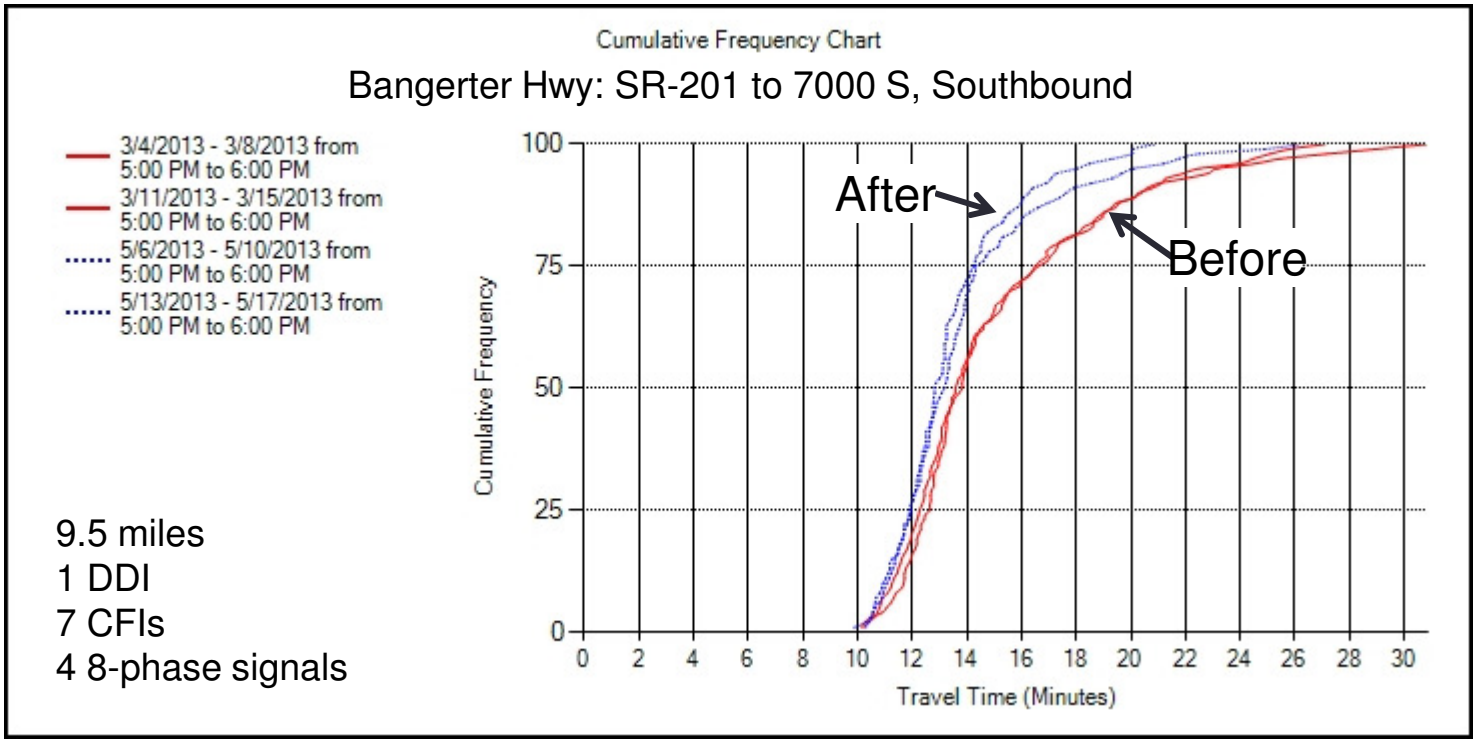
Metric: Approach Speeds

Detection Requirements: Wavetronix Advance Radar

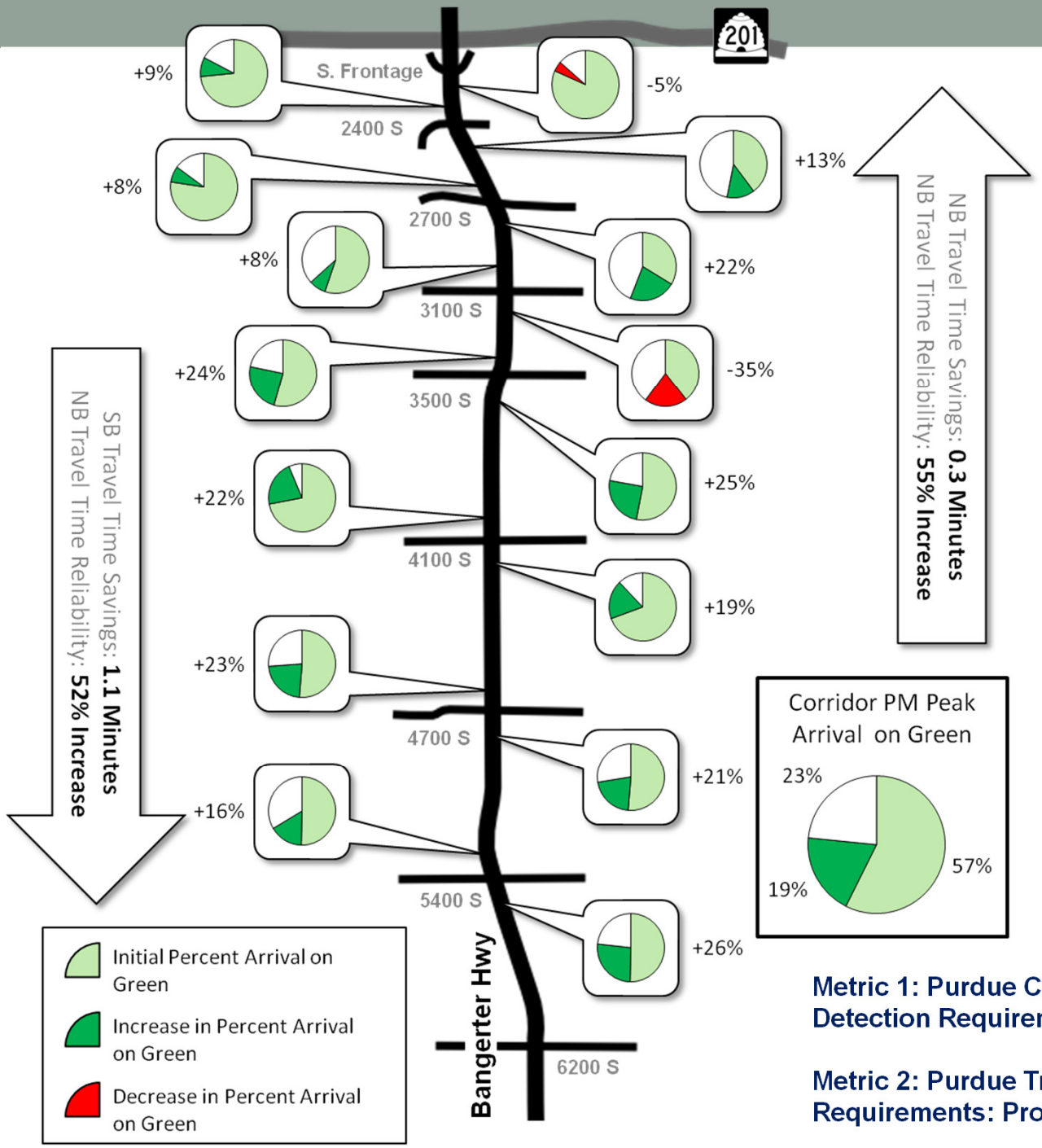
Measuring Corridor Travel Time – Cumulative Frequency

Before & after corridor evaluations using historical GPS travel time data from INRIX

Before Condition: SB Bangerter Hwy: SR-201 to 7000 S, SLC, UT – March 2013
After Condition: SB Bangerter Hwy: SR-201 to 7000 S, SLC, UT – May 2013



Metric: Purdue Travel Time Diagram
Detection Requirements: Probe Data Set



Metric 1: Purdue Coordination Diagram
Detection Requirements: Advance

Metric 2: Purdue Travel Time Diagram
Requirements: Probe data set

Executive Reports & Prioritizing

- *Are signal operations improving, staying the same, or getting worse and by how much?*
- *How does an agency most effectively prioritize resources and workload?*
- *What are our areas of most need?*

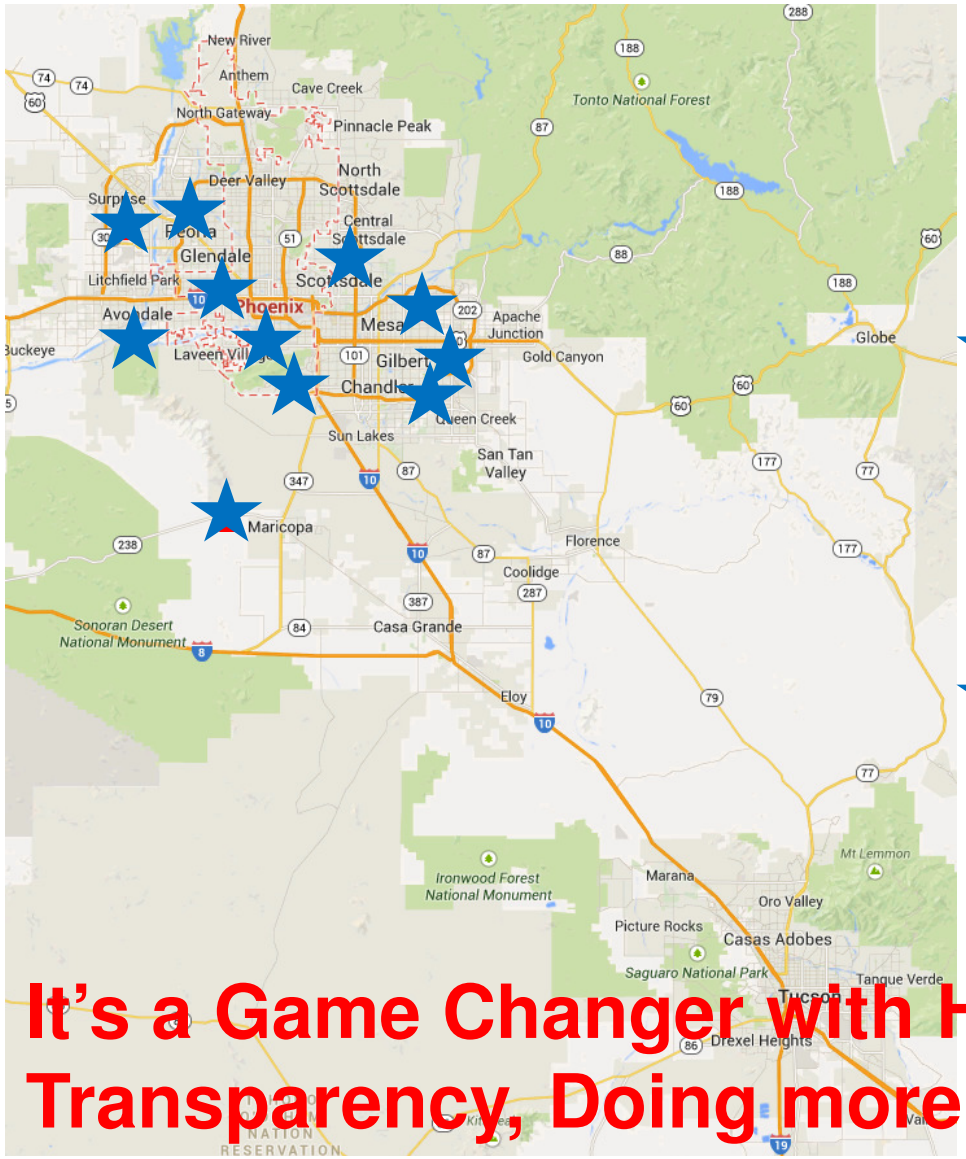
Statewide Summary 24 hours / day in Utah for August 2014

Month	Arrival on Red		Volume	Intersections	
Month	Percent	Platoon Ratio	Daily Average Per Approach	Total	Number of Approaches
Aug 2014	30%	1.16	10,740	414	843

- Region, corridor, and intersection summaries also available.
  - Prioritize coordination projects where they're needed the most.
- Engineers could now **directly measure** what previously they could only **estimate and model**.

Metric: Executive Reports
Detection Requirements: Advance Counters

SPM's for Arizona? Some Options!



UDOT donates SPM software for free and assists with setup.

- Option 1: Each city has their own separate SPM system.
  - ★ Costly: ~ $150K+
  - No sharing of data
- Option 2:
  - ▲ Each city has a small server (existing server).
  - ★ Small servers could upload data logs to 1 big server.
  - Total cost ~ $25K
    - Large benefits of sharing data with others

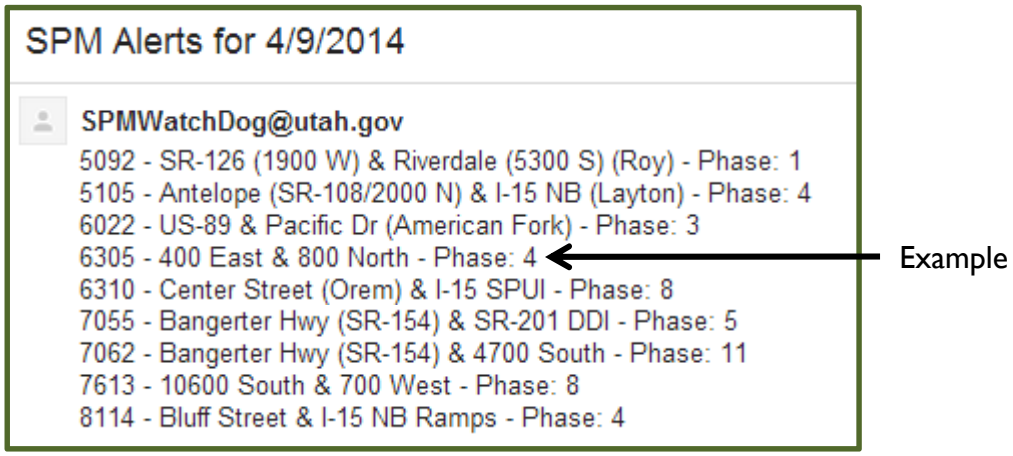
It's a Game Changer with Huge Benefits, Increased Transparency, Doing more with Less, and K-I-S-S!

Automated Traffic Signal Performance Measures

AASHTO Innovation Initiative (formally TIG) 2013 Focus Technology

Mission: Investing time and money to accelerate technology adoption by agencies nationwide

Alert Example: 100% Max Out

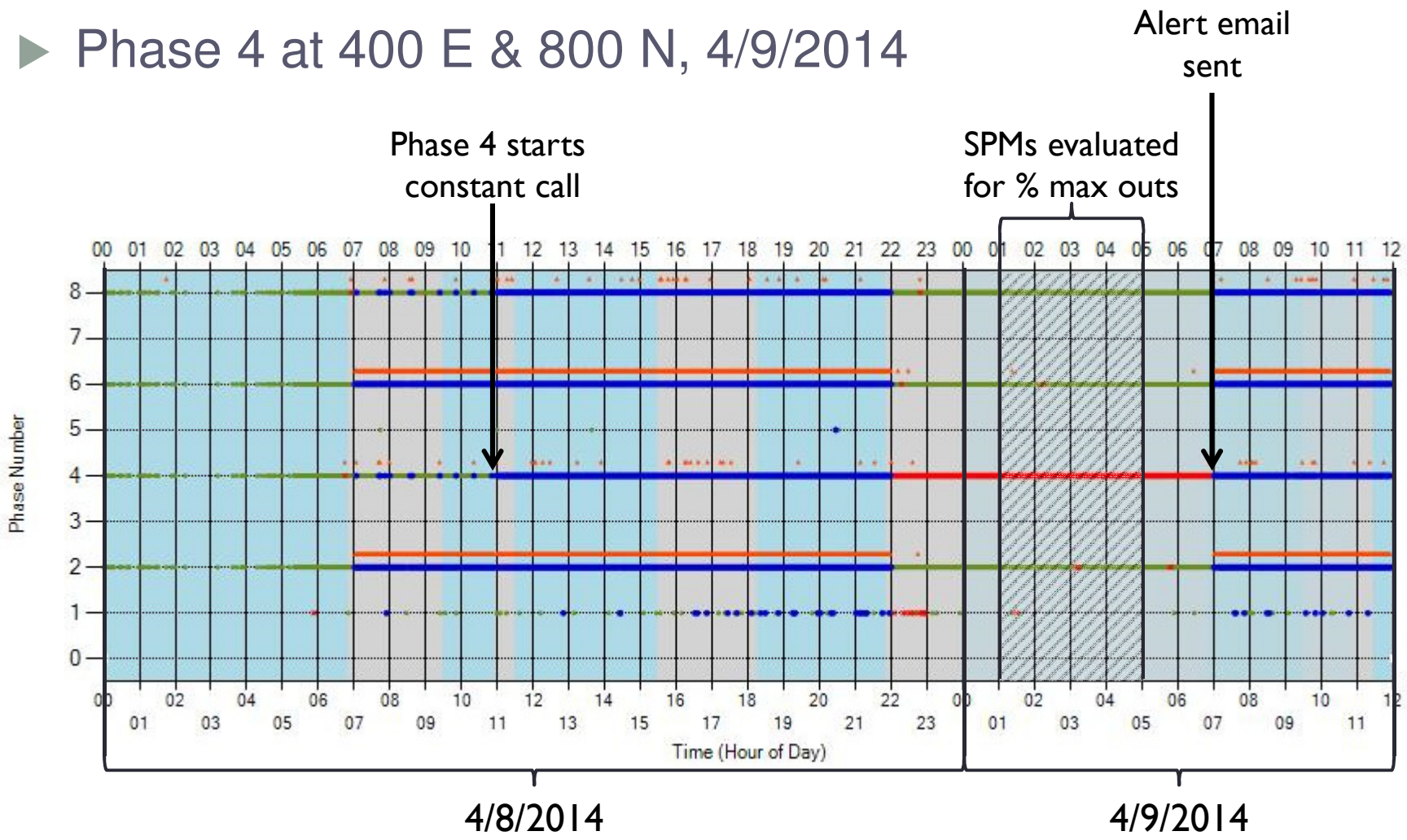


- Daily email at 7 a.m.
- Uses Purdue Phase Termination chart data
- Flags phases with >90% max-outs on each phase between 1 a.m. and 5 a.m.
- Compare to previous day's list. Only phases with new flags are sent in the email.

Metric: Purdue Phase Termination
Detection Requirements: None

Alert Example: 100% Max Out

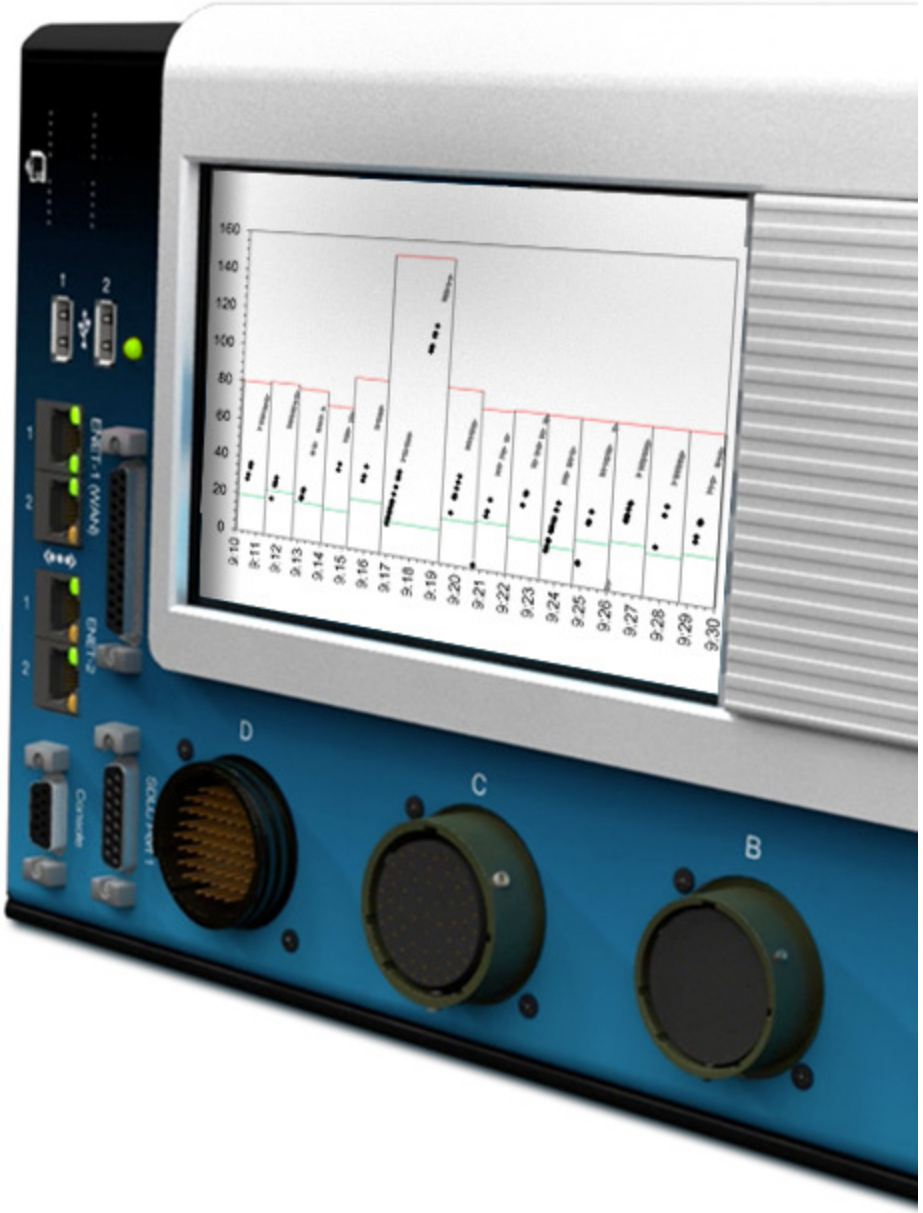
- Phase 4 at 400 E & 800 N, 4/9/2014



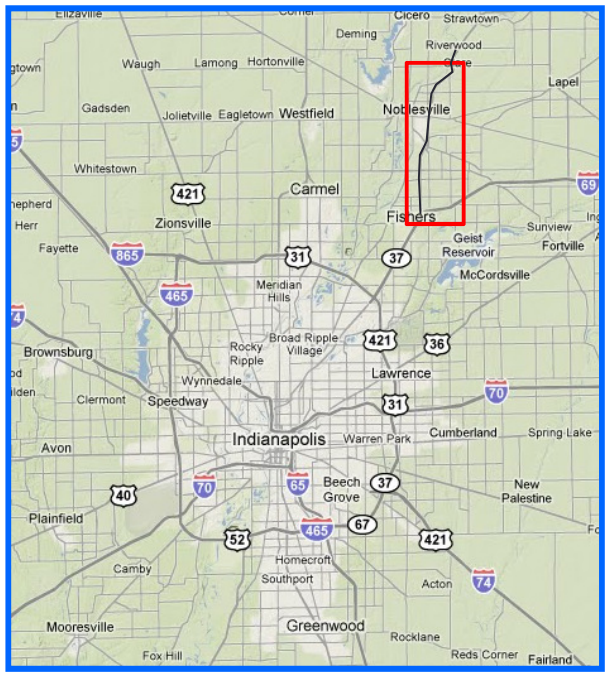
- Gap out
- Max out
- Force off
- Pedestrian activation (shown above phase line)
- Skip

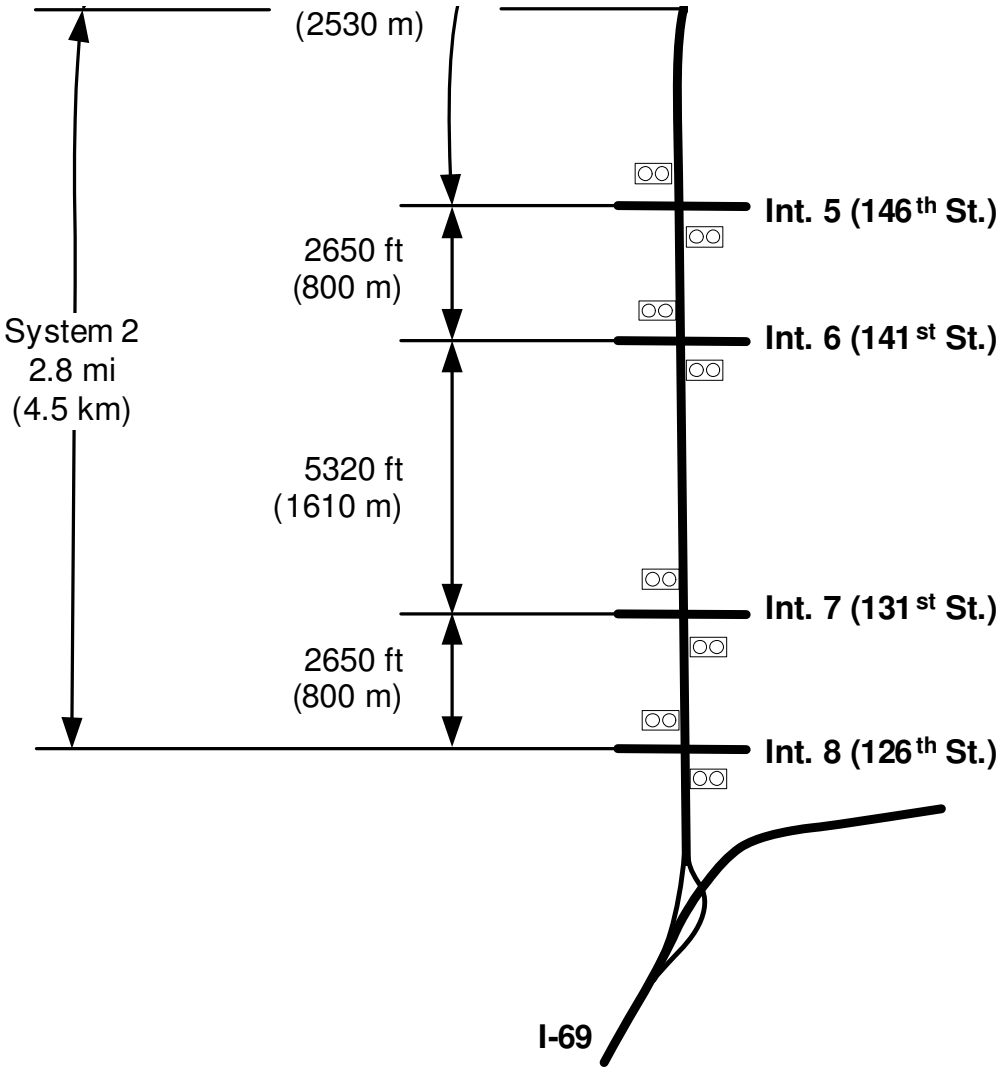
Metric: Purdue Phase Termination
Detection Requirements: None

Future of SPM's?

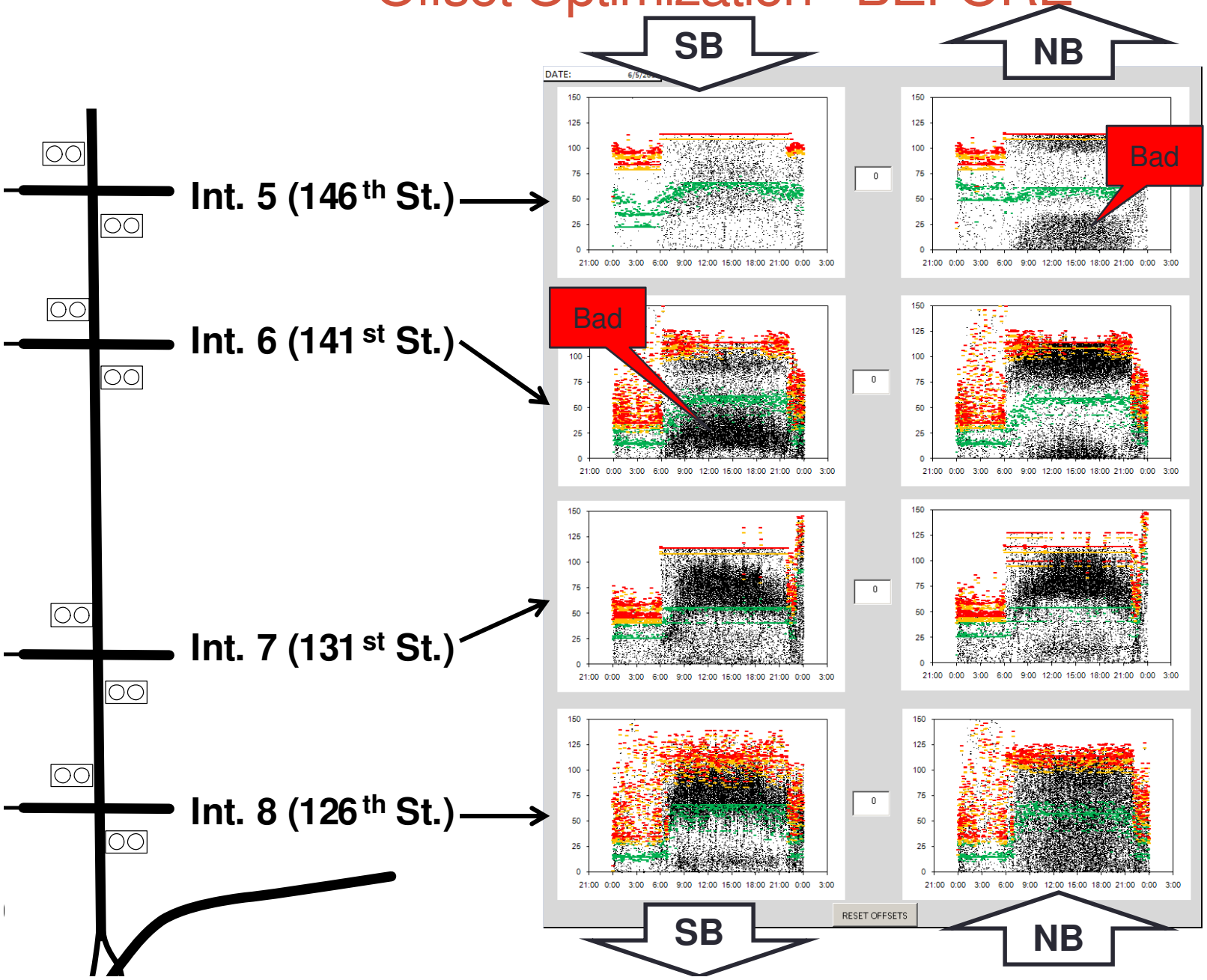


Offset Optimization Case Study

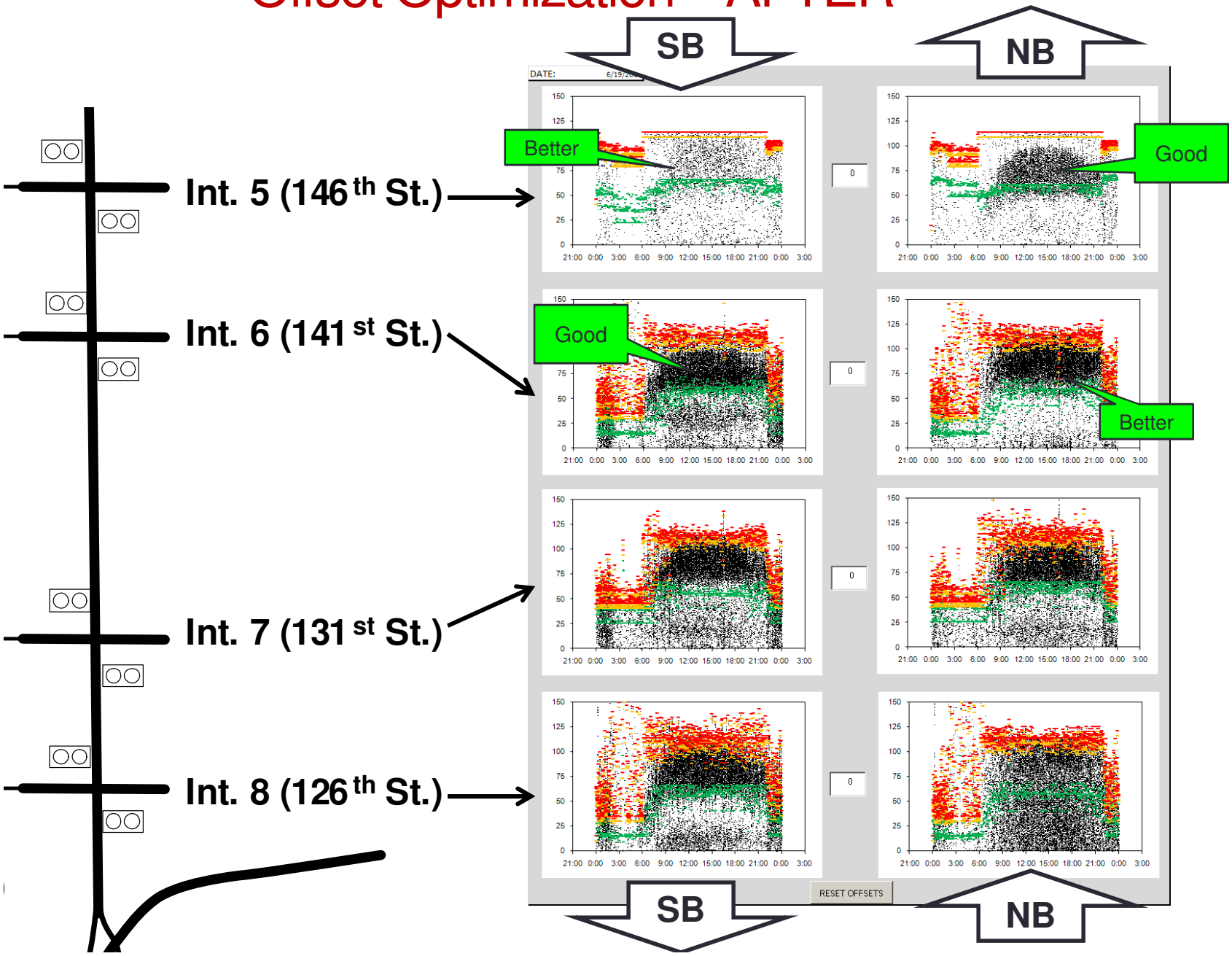




Offset Optimization - BEFORE



Offset Optimization – AFTER

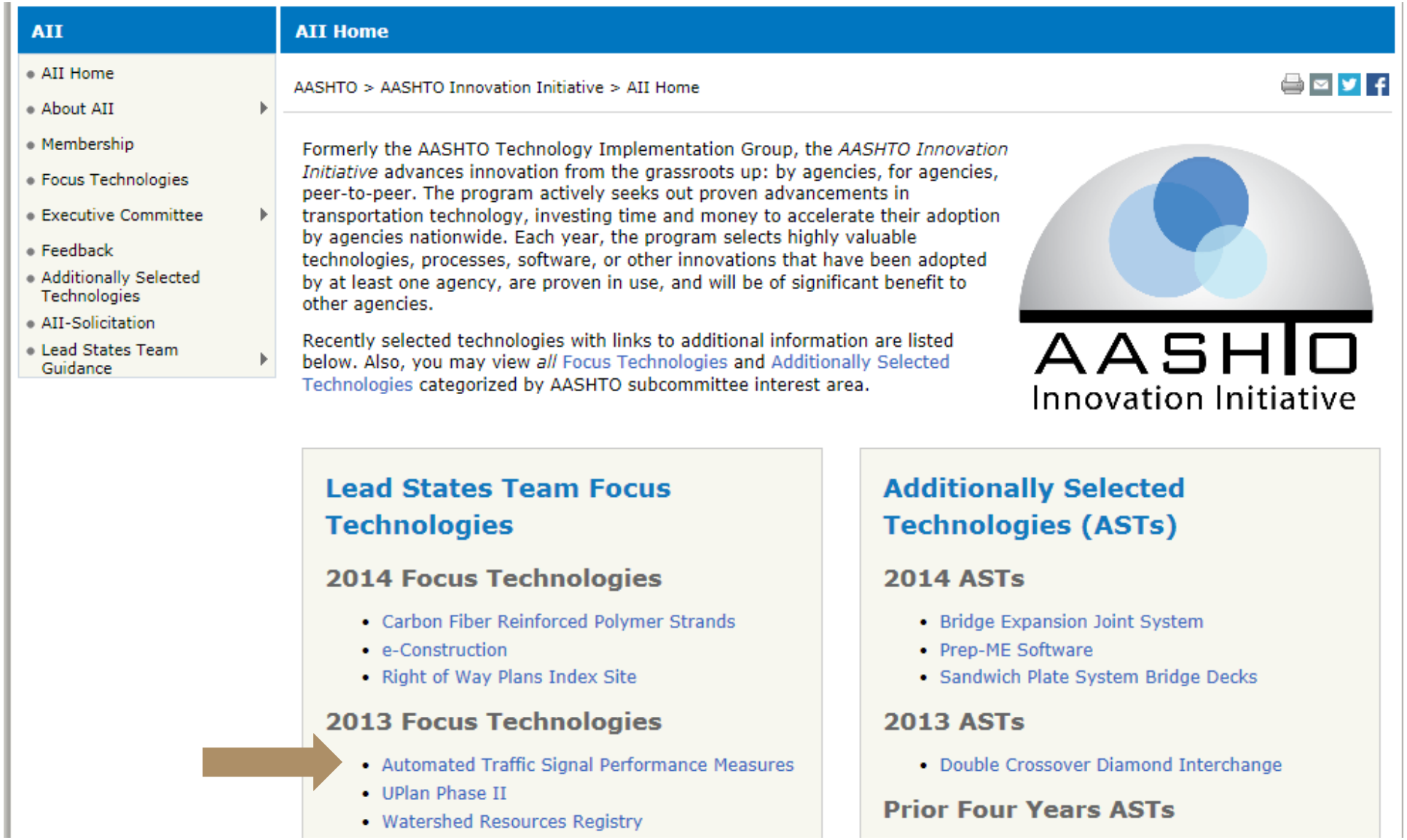


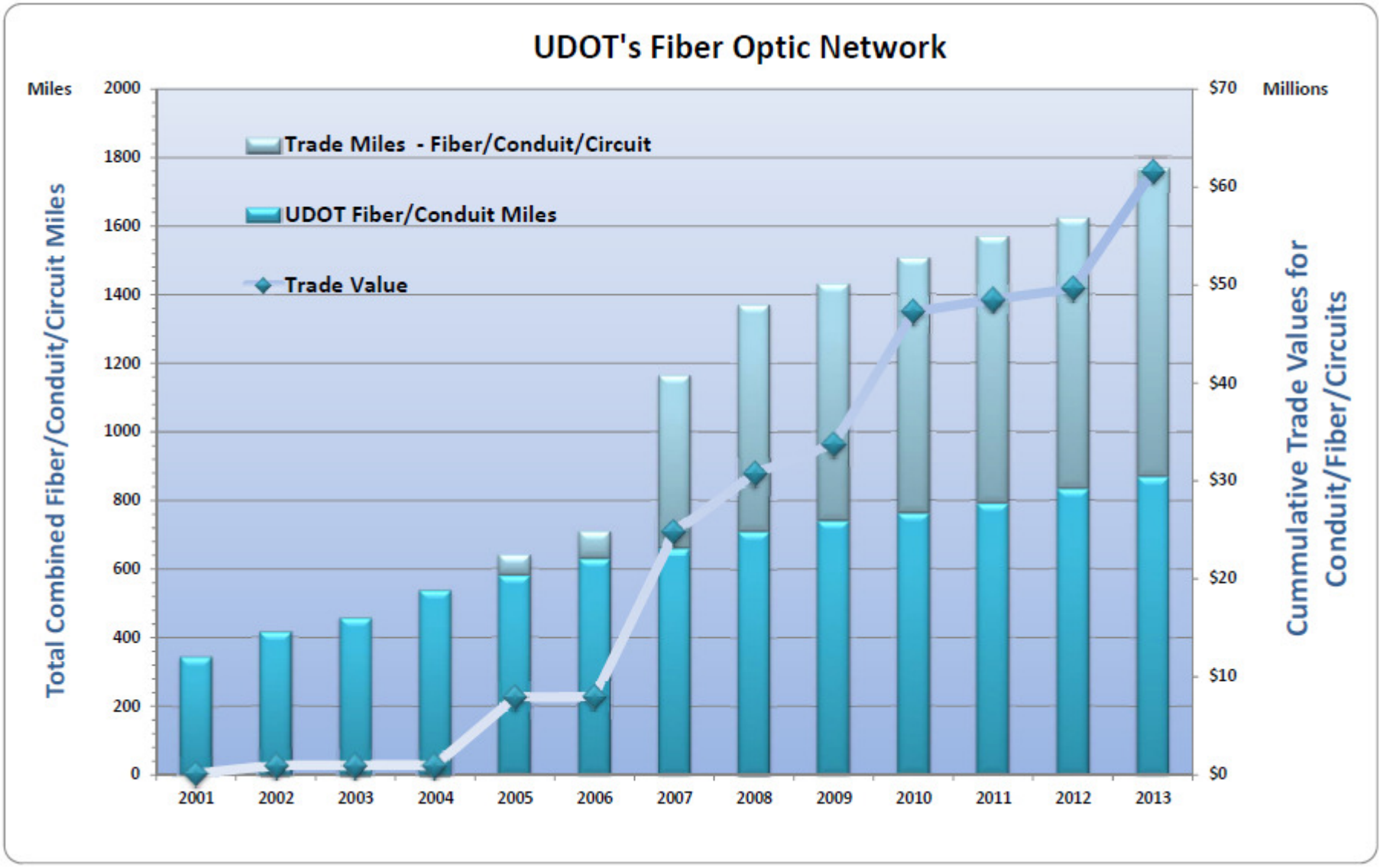
Standards & Requirements

- Controller specs and requirements to include Indiana/Purdue Hi Def Data Logger (http://docs.lib.purdue.edu/jtrpdata/3/)
- Controllers already with Indiana/Purdue Data Logger:
  - Econolite Cobalt: Any Version
  - Econolite ASC3 NEMA: V. 2.50+ & OS 1.14.03+
  - Econolite 2070 with 1C CPU Module: V. 32.50+
  - Intelight Maxtime: V. 1.7.0+
  - Peek ATC Greenwave 03.05.0528+
  - Trafficware 980ATC V. 76.10+
  - Siemens M50 Linux & M60 ATC
    - ECOM V. 3.52+
    - NTCIP V. 4.53+
  - McCain – In progress

http://udottraffic.utah.gov/signalperformancemetrics

Find out more: http://aii.transportation.org




UDOT's Fiber Optic Network
Miles
Millions
Total Combined Fiber/Conduit/Circuit Miles
Cummulative Trade Values for Conduit/Fiber/Circuits
Trade Miles - Fiber/Conduit/Circuit
UDOT Fiber/Conduit Miles
Trade Value
2000
1800
1600
1400
1200
1000
800
600
400
200
0
$70
$60
$50
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